Results of proximal humeral locked plating with supplemental suture fixation of rotator cuff

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**Hypothesis:** This study retrospectively reports the results of 81 patients with proximal humeral fractures that were treated operatively. We hypothesized that treatment of these injuries through a standardized technique of precontoured locked plating and supplemental tension band suture fixation would result in improved clinical outcomes.

**Materials and methods:** All patients were evaluated with a minimum follow-up of 1 year. Clinical assessment was performed postoperatively with American Shoulder and Elbow Surgeons (ASES) scores and active range of motion measurements. Radiographic parameters assessed included Neer fracture pattern, fracture union, hardware failure, the presence of avascular necrosis, and medial calcar length and stability. Fractures were classified as 4-part in 14 (17%), 3-part in 41 (51%), and 2-part in 26 (32%).

**Results:** The average ASES score was 80 (range, 27-100). The final range of motion averaged 131° of anterior elevation and 41° of external rotation. Fracture union was achieved in all patients, and there were no tuberosity failures. Complications included intraarticular screw penetration in 3 (3.7%) and avascular necrosis in 5 (6.2%).

**Discussion:** Locked plating and supplemental tension band fixation can lead to fracture union and favorable outcomes. Restoration of the medial calcar and supplemental suture fixation may decrease the incidence of hardware-related complications.

**Level of evidence:** Level IV, Case Series, Treatment Study.

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**Keywords:** Shoulder; proximal humeral fracture; locked plating

In attempts to better understand the nature of these failures, several authors have analyzed their outcomes and have provided recommendations and input to better address these difficult injuries. Much attention has recently been paid to the importance of the medial column for maintenance of stable fixation of proximal humeral fractures. Anatomic reduction and restoration of the medial calcar allows the medial column to both buttress and reduce the stresses of laterally based fixation. Gardner et al. first emphasized this concept by noting that when mechanical support of the inferomedial region of the proximal humerus

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was obtained, fracture subsidence was statistically reduced postoperatively. This was further confirmed in the work by Solberg et al.,\textsuperscript{36} where it was recognized that the presence of a metaphyseal segment in the region of the medial calcar greater than 2 mm was associated with better clinical outcomes and independent of Neer fracture type.\textsuperscript{25}

In addition to restoration of the medial calcar, other authors have advocated the addition of sutures to counter the natural deforming forces of the rotator cuff.\textsuperscript{1,2,8,11,27} The maximal contractile force of the rotator cuff is estimated to be 340 N.\textsuperscript{19} Over time, this repetitive force can predispose the fracture construct to varus displacement, collapse, and subsequent screw cutout.\textsuperscript{11} Incorporation of multiple sutures dispersed throughout the cuff and then tied to the plate can help mitigate these forces, similar to the concept applied in rotator cuff repairs.\textsuperscript{19} Unfortunately, despite the theoretic advantage, biomechanical and prospective studies are lacking and future research is warranted to better understand the role that suture may play.

The purpose of the current article, therefore, is to report the results of our retrospective review of open reduction and internal fixation of 2-, 3- and 4-part proximal humeral fractures treated with a previously described technique of locked lateral plating and supplemental suture fixation of the rotator cuff.\textsuperscript{1}

### Materials and methods

This study was approved by the Research and Education Review Board (IRB # 2005-008-323) of University Community Hospital, Tampa, Florida.

This multicenter study retrospectively reviewed all 2-, 3-, and 4-part proximal humeral fractures that were consecutively managed with a common technique of locked plate fixation and suture augmentation of the rotator cuff, a technique previously described by Badman et al.\textsuperscript{1} Between July 2004 and May 2007, 829 patients with proximal humeral fractures (International Classification of Disease, 9th edition code 812.00) presented through the clinics of the 3 senior authors. Of this group, 116 (14%) were managed operatively, with 88 (11%) treated with open reduction and internal fixation, 16 were managed with hemiarthroplasty (2%), and 12 (1%) were treated with reverse arthroplasty. The remaining 713 patients (86%) were managed nonoperatively (Table I).

All treating physicians were fellowship-trained shoulder and elbow surgeons and all used the same approach and surgical technique based on similar training and instruction. Head split fractures and isolated greater tuberosity fractures were excluded during the collection process. Other exclusion criteria included children, open fractures, polytrauma patients, segmental fractures or injuries with diaphyseal extension, and patients with less than 12 months of clinical follow-up. Surgical indications included all 3-part and 4-part fractures and all 2-part fractures with 100% displacement or varus malalignment greater than 30° off the neck-shaft angle.

Three patients died before fracture union and 4 were lost to follow-up, leaving 81 patients (58 women, 23 men) who met the inclusion criteria. The mean age was 60 years (range, 18-91 years). The mechanism of injury was a simple fall in 69, 5 motor vehicle accidents, 3 motorcycle accidents, and 4 bicycle accidents.

<table>
<thead>
<tr>
<th>Table I</th>
<th>Definition and characteristics of study group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Nonoperative</td>
<td>713 (86)</td>
</tr>
<tr>
<td>Operative</td>
<td>116 (14)</td>
</tr>
<tr>
<td>Hemiarthroplasty</td>
<td>16 (2)</td>
</tr>
<tr>
<td>Reverse shoulder arthroplasty</td>
<td>12 (1)</td>
</tr>
<tr>
<td>ORIF</td>
<td>88 (11)</td>
</tr>
<tr>
<td>ORIF (excluded)</td>
<td>7 (1)</td>
</tr>
<tr>
<td>Study group</td>
<td>81 (10)</td>
</tr>
</tbody>
</table>

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Preoperative imaging consisted of orthogonal radiographic views of the shoulder and fluoroscopic evaluation of all patients before performing open reduction and internal fixation (Fig. 1). These were used to classify fractures retrospectively according to the Neer classification by the 3 senior authors and by an independent fellowship-trained shoulder and elbow surgeon. Disagreements about fracture type were resolved by majority rule, or if a tie occurred, the fracture was classified according to the interpretation of the independent observer. Radiographic assessment of the integrity of the medial calcar according to the Hertel criteria (the presence of a medial calcar >8 mm or medial hinge displacement >2 mm) was also evaluated, and the learning points discussed by Shrader et al were considered when critically analyzing the radiographs (Fig. 2). Fractures were 2-part in 26 (32%), 3-part in 41 (51%), and 4-part in 14 (17%). Four glenoid rim fractures secondary to fracture dislocation were also managed with internal fixation at the time of the index procedure (one 3-part and three 4-part).

Patient information was obtained from inpatient and outpatient medical records. Operative reports were gathered to confirm that supplemental suture fixation was used in 100% of cases. In addition, we retrospectively tabulated and reviewed those cases where a structural allograft was incorporated into the fracture construct (Fig. 3). All treating surgeons routinely used a structural allograft. Its use was at the sole discretion of the treating surgeon and often based on intraoperative findings. No predetermined indications for the use of allograft were in place at the onset of the study.

Postoperative radiographic analysis was performed in all patients using standard orthogonal radiographs obtained at routine follow-up at 2, 6, 12, 24, and 52 weeks. Imaging consisted of a standard 4-view shoulder series, including anteroposterior, Grashey (true anteroposterior view of the glenohumeral joint), scapular Y, and axillary views. Preoperative and postoperative radiographs were retrospectively analyzed in a serial fashion by an independent observer to evaluate for fracture union, timing to fracture union, avascular necrosis, posttraumatic arthrosis, hardware-related complications, and identification of structural allograft use and incorporation.

At each routine follow-up visit all patients were assessed by the senior authors through patient interview, physical examination, and patient survey. This information was tabulated into a shoulder rating score according to the American Shoulder and Elbow

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**Figure 1** (A) Grashey view of a displaced 3-part proximal humerus fracture with displaced surgical neck and greater tuberosity. (B) True anteroposterior view of a displaced 3-part proximal humeral fracture with displaced surgical neck and greater tuberosity.

**Figure 2** Radiograph shows a 3-part proximal humeral fracture with an intact medial calcar greater than 8 mm in length.
Surgeons (ASES) that was obtained at each visit. The total score ranges from 0 to 100 points and is based on shoulder motion and patient self-evaluation.

**Surgical technique**

Open reduction and internal fixation was performed on all 81 patients using an operative technique previously described. Patients were treated with an anatomic proximal humeral locking plate, and the implants used in this series included 12 PHILOS plates (Synthes, West Chester, PA) and 69 S3 plates (Hand Innovations/DePuy, Warsaw, IN).

The patient was placed in a 30° elevated supine position on a radiolucent table, and orthogonal fluoroscopic images were obtained before the start of the procedure to ensure that adequate radiographic visualization could be obtained intraoperatively. A standard deltopectoral approach was used in each case. Fragment mobilization was achieved indirectly by placing a nonabsorbable heavy suture through the rotator cuff tendon adjacent to the tuberosity fragments with a No. 2 FiberWire suture (Arthrex, Naples, FL). The sutures were used to assist in manipulation of the tuberosity fragments. A minimum of 2 sutures were placed in each case, with at least 1 placed in the substance of the infraspinatus and at least 1 in the subscapularis tendons. The fracture pattern was then exploited to gain access to the joint.

The rotator interval was opened and a subpectoral biceps tenodesis was routinely performed. Palpation of the supraglenoid tubercle aided as a landmark to assist in proper reduction of the humeral head segment, which is commonly sitting retroverted. Once reduced, a provisional Kirschner wire was frequently placed through the upper head segment with purchase into the glenoid to assist with initial maintenance of the reduction. The reduction was verified using orthogonal fluoroscopic imaging and was repeated until as near an anatomic restoration of the anatomy as possible was achieved, with close attention paid to the neck shaft angle and reduction of the medial calcar.

Our routine reduction sequence was to first elevate the head and to place a structural graft when the operative surgeon believed it was indicated. Intraoperative findings that influence the use of a structural graft include medial calcar comminution, poor quality bone, presence of a large metaphyseal void after reduction of the head segment, or varus-impacted fractures. Use of the graft throughout this study period was purely subjective, however, and not based on any predetermined parameters, so we cannot currently make any firm indications for its use.

The shaft was then pinned to the head segment. The tuberosities were reduced under fluoroscopic guidance by tensioning the previously placed sutures, and Kirschner wires were used as necessary to keep the fragments in place. After verification of the reduction, the plate was applied in neutralization mode. The first shaft screw placed was through the oblong hole to allow minor height adjustments of the plate. This was followed by placement of all unicortical locked screws into the humeral head with the goal of maximizing fixation in the inferior head quadrants and avoiding screw placement within 5 mm of the articular surface. When possible, larger diameter blunt-tipped pegs were used. Although not available in all systems, we believe they are advantageous to a screw in the event of hardware penetration where a blunt tip would be potentially less destructive than the thread of a screw. The remaining distal shaft screws were placed in routine bicortical fashion. Supplemental suture fixation was effected by tying the nonabsorbable sutures to the plate through the suture eyelets. The shoulder was ranged under orthogonal fluoroscopic imaging to ensure fracture stability and appropriate screw lengths before wound closure.

**Postoperative management**

The postoperative regimen consisted of a shoulder immobilizer for the first 4 to 6 weeks, depending on the fracture pattern and degree of comminution. Patients with 2-part fractures were generally started on passive-assisted range of motion once the wound was healed after 2 weeks; however, 3- and 4-part fractures were strictly immobilized until initial healing was demonstrated on follow-up imaging. Elbow and wrist range of motion exercises were encouraged initially; however, shoulder range of motion including

![Figure 3](image-url)
pendulums were avoided until wound healing was confirmed and sutures were removed by postoperative day 10 to 14. With confirmation of wound healing, the patient was allowed to perform pendulum exercises for hygiene purposes. Formal physical therapy was generally initiated after the 6-week follow-up visit.

Statistical analysis

Patient data were statistically analyzed to determine association between variables and complication outcome. Tests for significance were performed using a t test for continuous variables and the Fisher exact test for categoric variables. Paired samples comparing differences between groups based on age older or younger than 65 years, fracture type, ASES score, sex, range of motion, and incidence of complications were analyzed using the Wilcoxon test. The effect of Neer fracture type on the decision to use a structural intramedullary allograft and the incidence of complications based on subgroup (Neer fracture type, sex, age, and implant type) were measured with a $\chi^2$ analysis of proportions test. All statistical analyses were performed using MedCalc 10.1.0.0 software (MedCalc Software, Mariakerke, Belgium). All tests were reported as significant if $P < .05$, and 95% confidence intervals were calculated.

Results

The study included 81 patients, and all went on to union within 6 months of the index procedure. The average follow-up was 22.8 months (range, 12-65 months). Follow-up exceeded 2 years in 30 patients (37%). The average ASES score was 80 (range, 27-100). The average forward elevation was 131$^\circ$ (range, 60°-180°), and external rotation was 41° (range, 0°-90°). Analysis of radiographs demonstrated the mean humeral neck shaft angle was 128° and revealed no cases of greater tuberosity fixation failure.

Patients were subcategorized (Table I) according to age older or younger than 65 years, fracture type, sex, and Philos vs S3 plate implant. Each subgroup was statistically analyzed for differences in outcome based on range of motion, ASES score, incidence of avascular necrosis, and overall complication rate. There were no statistical differences in outcome by implant choice, sex, or Neer fracture type. Age did have a significant effect on several factors, including range of motion, choice to use an allograft, and overall incidence of complications. Stratification by age groups showed that patients older than 65 had a lower mean postoperative forward elevation (121$^\circ$ vs 141$^\circ$, $P = .014$) and were more frequently treated with an allograft. A structural graft was incorporated in 45 patients (55.6%); however, use was 65% in patients older than 65 compared with 45% in patients 65 and younger ($P = .024$). Interestingly, patients younger than 65 had a higher overall incidence of complications and a higher probability of undergoing capsular release for stiffness ($P = .024$). Women in this study were also significantly older than the men (67 vs 44 years, $P < .0001$), comprising a significantly higher proportion in those older than 65 compared with patients younger than 65 (91% vs 57%, $P = .001$).

Finally, patients that presented with a fracture pattern consisting of a medial calcar of less than 8 mm and a disrupted medial hinge of greater than 2 mm were statistically more likely to receive a structural intramedullary allograft ($P = .0003$). An allograft was used in 34 of the 46 patients (74%) who met this radiographic criterion compared with 11 of 34 (32%) who did not.

Complications

Five patients (6%) had evidence of varus collapse but remained satisfied with their results and did not require further intervention (Table II). An allograft was used in 3 of the 5 patients with collapse. No correlation between age or fracture type could be made for those that had subsequent collapse. Avascular necrosis was radiographically observed in 5 patients (6.2%), comprising two 4-part fractures, one 3-part fracture, and two 2-part fractures, with one being an anatomic neck variant. Two of these patients were asymptomatic and the other 3 were painful, with humeral head collapse and late intraarticular screw penetration.

All patients with late collapse had secondary comorbidities that may have contributed to their outcome. One patient was a 77-year-old obese woman with a 2-part fracture that was not treated with a graft. A collapse was demonstrated at 6 months, and she was subsequently converted to a hemiarthroplasty. The second patient was a 51-year-old woman with emphysema and home oxygen-dependence who had a 3-part fracture that was treated with a graft. Her fracture demonstrated subsidence, with eventual collapse and hardware penetration at 6 months. She was converted to a successful reverse shoulder arthroplasty 10 months out from the initial procedure. The final patient was a 50-year-old woman with steroid dependence for chronic respiratory issues who had a 2-part anatomic neck fracture that was also treated with a graft. Her fracture demonstrated avascular necrosis at 8 months and hardware penetration at 12 months. She underwent prominent screw removal and arthroscopic capsular release at 12 months postoperatively, with overall good outcome. No cases of plate failure, screw breakage, or infection were encountered in the present study (Table I).

A final complication reported was patient dissatisfaction due to posttraumatic stiffness. Four patients (5%) elected for arthroscopic capsular release at an average of 13 months postoperatively. Indications for surgery were pain and limited motion combined with failure of conservative management, including therapy and steroid injections. This group consisted of one 2-part, two 3-part, and one 4-part fracture. Three patients were not able to achieve forward elevation greater than 90° before capsular release. Surgical intervention resulted in improved motion and satisfaction. The average preoperative forward elevation was 94° with postrelease measurements, which averaged 145°.
Discussion

Proximal humeral fractures occur frequently in the elderly population, accounting for 5% to 9% of all fractures.²³,³⁷,⁴⁴ Owing to the typical osteoporotic nature of the bone and the deforming forces of the surrounding rotator cuff, these fractures can pose a challenge for the treating surgeon. Treatment is often guided by the relative displacement of the anatomic fragments. Fractures that are nondisplaced have historically been treated conservatively, with generally good outcomes, and displaced fractures, as defined according to Neer’s criteria, have been treated operatively with mixed results.* Although many techniques have been described, including percutaneous fixation, standard plate-and-screw fixation, intramedullary fixation with rods or pins, tension band techniques, or blade plate fixation, the overall outcomes have been sporadic, with no definitive solution identified.

Treatment of these fractures has greatly been aided by the advent of anatomic fixed-angle locking plates (Table III). Although many techniques have been described, including percutaneous fixation, standard plate-and-screw fixation, intramedullary fixation with rods or pins, tension band techniques, or blade plate fixation, the overall outcomes have been sporadic, with no definitive solution identified.

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Despite their proven biomechanical advantages, several recent studies have noted that these plates are not the panacea for all injuries, raising concerns about such treatment in elderly patients.²,⁶,¹¹,²¹,²⁷,³¹ Egol et al⁸ presented 51 patients treated with the PHILOS plate and reported a 24% overall complication rate, with screw cutout occurring in 16%. In their series, 88% of patients with screw cutout were older than age 60, and age and poor bone quality were both felt to be contributing factors to this complication. Similarly, Owsley et al²⁷ reported a 36% complication rate in 53 patients, with intraarticular screw penetration occurring in 23% and a statistically significant higher radiographic complication rate noted in patients older than 60 years. Owing to the inherent difficulties with internal fixation in the elderly, who dominate this injury pattern, several authors maintain that most 3- and 4-part fractures are best managed with hemiarthroplasty in these patients.¹²,²⁰,²⁶,³¹,⁴²

The use of suture is not a new concept, with its role recently emphasized in several publications (Table II).¹,²,⁸,¹¹,²⁷ Some authors have even demonstrated that proximal humeral fractures can be amenable to suture fixation alone, with good outcomes.⁶,²⁹ The natural force of the rotator cuff has been estimated to be at least 340 N.¹⁹ The current trend in orthopedics has been to use braided nonabsorbable polyblend suture material, which is available from various manufacturers. The average load to failure, depending on knot type for all of these sutures, is well over 100 N.⁴⁰ The incorporation of multiple sutures, therefore, should theoretically counter the effect that the rotator cuff can impose on fracture stability postoperatively. In the past, many surgeons failed to recognize the effect of such forces and relied purely on screw fixation alone to maintain fracture stability. Unfortunately, due to the osteoporotic nature of many of these injuries, the greater tuberosity is often just a shell of bone, and adequate fixation with a screw cannot always be obtained. Failure to recognize this may have contributed to the higher-than-expected failure

### Table II  Group complications

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age</th>
<th>Sex</th>
<th>Fracture type</th>
<th>Hertel criteria</th>
<th>Allograft strut</th>
<th>Complications</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>80</td>
<td>Female</td>
<td>3-part</td>
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<tr>
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<td>56</td>
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<td>Capsular release</td>
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<tr>
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<td>59</td>
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<td>4-part</td>
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<td>No</td>
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<td>None</td>
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<td>Female</td>
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<td>AVN, 2° screw penetration</td>
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<td>Yes</td>
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<td>Male</td>
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<td>Yes</td>
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<td>50</td>
<td>Female</td>
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<td>46</td>
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<td>78</td>
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<td>Yes</td>
<td>AVN, 2° screw penetration</td>
<td>Revisited to reverse arthroplasty</td>
</tr>
</tbody>
</table>

AVN, avascular necrosis.

* Hertel criteria involves a displaced medial hinge >2 cm and a medial calcar <8 mm in length.

* References 3-5,9,13,15-17,22,24,26,28,31,33,38,39,41,42,45
rates and hardware complications evident in many of the earlier series. Biomechanical studies on the role of suture augmentation in a fracture model are presently lacking, and a study is currently underway at our institution to evaluate the effect it provides in aiding and maintaining fracture reduction.

In addition to counterbalancing the forces of the rotator cuff, another element that can improve the outcomes of proximal humeral fracture fixation is restoration of the medial calcar segment. Gardner et al. reported that reproduction of the medial calcar should decrease the high complication rates reported with locked plates. When an intact medial calcar was present in their series, a 6% incidence of hardware penetration was noted compared with a 29% incidence when medial support was absent. In situations of prominent comminution where the medial column cannot be adequately restored to help support the head segment, we have found that use of a structural intramedullary allograft can aid greatly in fracture reduction. As further emphasized by Gardner, the intramedullary allograft can support the medial hinge and also oppose the varus stresses that predispose for head collapse and subsequent hardware penetration.

Retrospectively, we were interested in specific variables that might have contributed to our decision to incorporate a structural allograft at the time of surgery. We found that when the Hertel criteria were used and 3 independent surgeons assessed the preoperative radiographs for the presence of a medial calcar greater than 8 mm or the presence of a disrupted medial hinge, an allograft was statistically most likely to be incorporated in those fractures with a short calcar segment (<8 mm) and a medial hinge displacement (>2 mm). We also demonstrated a statistical significance in the decision to use structural allograft in patients aged older than 65 years. This likely reflects the tendency to encounter poorer bone stock in this age group. Owing to the lack of a control group and the retrospective nature of our analysis, however, specific recommendations about the decision to use allograft cannot be currently made. Further evaluation with a prospective study or a biomechanical comparison would greatly assist in future indications.

Our current series overall demonstrated a 3.7% incidence of hardware complications, a 6.2% incidence of avascular necrosis, and a 5% incidence of posttraumatic contracture necessitating further surgery. The hardware complications were late and related to collapse of the humeral head secondary to avascular necrosis. One difference that may explain a lower incidence of hardware-related complications is the consistent use of supplemental suture fixation in our series. In addition, we noted an increased use of structural allograft (56.3%) in our series compared with others previously reported. We feel strongly that by incorporating suture fixation of the rotator cuff and with liberal use of allograft in fractures with medial comminution, we were able to avoid head collapse by countering the deforming forces and restoring medial stability. This is, once again, purely hypothetical, and a biomechanical study is presently underway to demonstrate if our assumption is valid.

Our incidence of avascular necrosis is comparable with other series and was interestingly not higher in 4-part fractures. In fact, all fourteen 4-part fractures united and none required revision. This further supports the notion suggested by Lee and Hansen and Hertel et al. that in the presence of rigid stable fixation, revascularization of the head fragment may still be possible through creeping substitution, regardless of the fracture type or degree of displacement.

We reported postoperative stiffness as a complication. Although some surgeons would argue that stiffness by itself in a fracture setting should not be considered a poor outcome, we felt it was warranted to report it as a complication because of its relative frequency (5%). Of interest was that postoperative stiffness necessitating further surgery was statistically higher in the younger age group. We believe that this is

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**Table III** Comparison of recent studies using locked plating for proximal humeral fractures

<table>
<thead>
<tr>
<th>Study</th>
<th>Pts (No.)</th>
<th>Avg Age (y)</th>
<th>Avg F/U (mon)</th>
<th>Plate</th>
<th>Grafts</th>
<th>Tension banding</th>
<th>Revision surgery</th>
<th>Screw penetration</th>
<th>AVN</th>
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<td>51</td>
<td>61</td>
<td>16</td>
<td>Synthes</td>
<td>Cancellous chips/calcium phosphate cement</td>
<td>Yes</td>
<td>8</td>
<td>8</td>
<td>2</td>
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<td>Moonot21</td>
<td>32</td>
<td>59.9</td>
<td>11</td>
<td>Synthes</td>
<td>DBM nonstructural</td>
<td>NR</td>
<td>4</td>
<td>2</td>
<td>1</td>
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<td>Owsley27</td>
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<td>52</td>
<td>31</td>
<td>Synthes, Zimmer, Stryker</td>
<td>NR</td>
<td>Yes</td>
<td>7</td>
<td>12</td>
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<td>Bigorre2</td>
<td>99</td>
<td>62.8</td>
<td>17.8</td>
<td>Surfex</td>
<td>No</td>
<td>Yes</td>
<td>7</td>
<td>NR</td>
<td>7</td>
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<tr>
<td>Gardner11</td>
<td>35</td>
<td>62</td>
<td>7</td>
<td>Synthes</td>
<td>9 Norian cement</td>
<td>Yes</td>
<td>4</td>
<td>6</td>
<td>NR</td>
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<td>Duralde7</td>
<td>22</td>
<td>50</td>
<td>37</td>
<td>Synthes</td>
<td>Cancellous allograft</td>
<td>Yes</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Current study</td>
<td>81</td>
<td>60</td>
<td>22.8</td>
<td>Synthes, DePuy</td>
<td>45 structural allografts</td>
<td>Yes</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

AVN, avascular necrosis; DBM, demineralized bone matrix; F/U, follow-up; NR, not reported.

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1. References 3-5,9,12,13,15-17,21,22,26,28,33,38,39,41,45
a function of younger patients having greater expectations of achieving normalcy after surgery and demand more of their shoulders than elderly patients. In fact, 10 additional patients in the group aged 65 years and older (average age, 81) had forward flexion measuring less than 90° (average, 82°) but remained satisfied with their outcome (average ASES, 72.4). This finding stresses the notion that despite fracture union and a good radiographic outcome, full return of motion may not be a realistic goal and patients should be educated on this preoperatively, especially in the younger active group.

A potential criticism and etiology of the stiffness in our series can be attributable to our conservative postoperative regimen of immobilization. Although this may contribute to stiffness, we contend that healing of the fracture is the primary goal of the surgical intervention, with most patients demonstrating good return of motion regardless of fracture type. Our slow rehabilitation may also be a critical factor in our relatively low screw cutout (3.7%) compared with a recent meta-analysis where the average incidence was 11.6%.43 Furthermore, we believe that wound complications can be greatly reduced by immobilizing the patients, which is emphasized by the fact that we had no wound complications in the present series.

Conclusions

Our results demonstrate that open reduction and internal fixation of proximal humeral fractures leads to predictable fracture union and favorable functional outcomes. In the current series of 81 patients, we report a 3.7% incidence of hardware complications, which is substantially lower than a recent meta-analysis of 11.6% by comparison. We believe that use of a structural allograft in the setting of severe osteopenia in conjunction with suture fixation of the rotator cuff and a routine surgical technique that focuses on reduction of the medial calcar can mitigate the potential complications inherent with this injury. We acknowledge the weaknesses of our study, which include its retrospective nature and the subjective use of an allograft. Further peer-reviewed biomechanical and prospective studies are necessary to corroborate the importance of suture augmentation and the justification for structural allograft in treatment of these complex injuries.

Disclaimer

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