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Title: Complications, reoperations, and outcomes of proximal humerus open reduction internal fixation in a non-geriatric patient cohort.

Objectives: Proximal humerus fractures are common injuries with extensive debate regarding optimal treatment. Most of the literature has focused on the treatment of geriatric proximal humerus fractures, in which nonoperative management, open reduction internal fixation (ORIF), and arthroplasty are viable treatment options. However, there is a relative paucity of results in the literature regarding management of proximal humerus fractures in non-geriatric patients. Due to younger age and higher functional demands, nonoperative treatment and arthroplasty may be less favorable in this demographic. Our objective was to examine the postoperative complications, reoperations, and outcomes of proximal humerus ORIF in a non-geriatric patient cohort.

Methods: We performed a retrospective review using CPT code 23615 to identify patients undergoing proximal humerus ORIF with a lateral locking plate at a single institution from 2014 to 2024. Inclusion criteria included age between 18 and 60 years with at least 3 months follow-up. Exclusion criteria included patients undergoing isolated greater tuberosity fixation or fixation with intramedullary nailing. Demographics, surgical treatment information, and postoperative course were recorded by chart review. A radiographic analysis was performed including initial head-shaft angle, greater tuberosity height, screwtip-joint distance, and calcar-screw distance. Patient reported outcomes (PROs) including SANE and VAS scores were recorded by PatientIQ.

Results: Our study included 106 consecutive patients. Patient demographic, fracture pattern characteristics, and surgical information are summarized in table 1, and PRO values are summarized in table 2. Notably, mean age was 44.5 years and mean follow-up was 222.9 days. Radiographic union was 97.2%. We found a postoperative complication rate of 37.7%, and a reoperation rate of 12.2%. Factors associated with the development of a postoperative complication included Medicare/Medicaid insurance ($p = 0.02$), varus reduction ($p = 0.01$). Postoperative stiffness was associated with treatment from a trauma fellowship-trained surgeon ($p = 0.004$), however there was no association between fellowship training and need for reoperation ($p = 0.3$). Varus reduction was associated with need for reoperation ($p = 0.01$). The most common complication was postoperative stiffness (23.5%) for which only one patient underwent a postoperative intervention consisting of a corticosteroid injection. Six patients (5.6%) had a postoperative complication requiring a major reoperation: 1 infected nonunion, 1 aseptic nonunion, 2 cases of avascular necrosis (AVN), 1 acute loss of fixation, and 1 malunion leading to bony impingement. Seven patients (6.6%) underwent a minor reoperation consisting of hardware removal: 4 due to intraarticular screw penetration, 3 due to lateral shoulder pain. There was one postoperative axillary nerve neuropraxia which resolved with observation, and one upper extremity deep vein thrombosis treated with therapeutic anticoagulation uneventfully. Of the 10 patients who sustained a fracture dislocation, 1 patient required reoperation due to AVN. Fracture pattern severity, presence of a head split fracture, calcar comminution, or fracture dislocations were not associated with the development of a postoperative complication or reoperation. There were no postoperative losses of reduction, regardless of initial reduction quality, besides one acute loss of fixation in a polytrauma patient with multiple-extremity injuries.

Discussion: This study is, to our knowledge, the largest retrospective review of proximal humerus ORIF consisting of lateral locked plating in a non-geriatric patient cohort in the literature. We demonstrate a high rate of radiographic union with a low rate of complications requiring reoperation, as well as significant improvements in multiple PROs. While postoperative stiffness was the most common complication, it only required an additional intervention (nonsurgical) in one patient. Other complications including AVN, nonunion, and intraarticular screw penetration occurred at a lower rate than previously described in the literature. Our results support the use of lateral locked plating for proximal humerus fractures in this demographic as a reliable treatment strategy and help to council patients regarding expected postoperative course, outcomes, and potential risks.

Table 1. Population Characteristics (total cohort, n = 106)

Age (Mean ± SD, years)	44.5 ± 11.6
Gender (n, %)	
Male	49 (46.2%)
Female	57 (53.7%)
Follow-up Length (Mean ± SD, days)	222.9 ± 255.8
BMI (Mean ± SD)	27.9 ± 7.7
Postoperative Complication (n, %)	40 (37.7%)
Postoperative Reoperation (n, %)	13 (12.2%)
Interval between injury and surgery (Mean ± SD, days)	10.7 ± 7.2
Smoking Status (n, %)	
Smoker	19 (17.9%)
Non-smoker	87 (82.1%)
Diabetic Status (n, %)	
Diabetes Mellitus	6 (5.7%)
No Diabetes Mellitus	100 (94.3%)
Insurance Type (n, %)	
Private	69 (65.1%)
Medicare/Medicare	29 (27.4%)
None	8 (7.5%)
Surgeon Fellowship Training (n, %)	
Shoulder Elbow	49 (46.2%)
Trauma	54 (50.9%)
Sports Medicine	3 (2.8%)
Fracture Pattern (n, %)	
2-part SN	41 (38.6%)
3-part SN/GT	41 (38.6%)
3-part SN/LT	4 (3.8%)
4-part	33 (36.7%)
Mechanism of Injury (n, %)	
High	65 (61.3%)
Low	41 (38.7%)
Fracture Dislocation (n, %)	10 (9.4%)
Head Split Component (n, %)	9 (8.5%)
Calcar Comminution (n, %)	43 (40.6%)
Surgical Time (Mean ± SD, minutes)	90.8 ± 40.1
Blood Loss (Mean ± SD, mL)	136.5 ± 117.3
Reduction Quality (n, %)	
Adequate	84 (79.2%)
Valgus	12 (11.3%)
Varus	10 (9.4%)

SD, standard deviation; BMI, body mass index; SN, surgical neck; GT, greater tuberosity; LT, lesser tuberosity; ml, milliliters; surgical time measures from incision to initiating of closing; reduction quality was measured by head shaft angle where varus < 120 degrees, valgus > 150 degrees, and adequate between 120 to 150 degrees.

Table 2. Preoperative and postoperative outcomes measures (Mean ± SD).

	Pre-op	3 month	6 month	1 year	2 years
ASES	20.3±16.9	67.5±19.4	84.0±10.7	78.8±28.3	85.6±18.5
SANE	2.0±4.8	53.4±20.7	79.8±9.9	82.5±6.4	79.0±20.9
VAS	5.8±2.9	3.0±2.4	1.6±1.6	2.2±2.8	1.8±2.2