Comparison of Locked Plate Fixation and Nonoperative Management for Displaced Proximal Humerus Fractures in Elderly Patients

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Abstract

Use of locked plate fixation for proximal humerus fractures in elderly patients has increased markedly in recent years. We conducted a study to compare outcomes of operative (locked plate fixation) and nonoperative management of these fractures.

From our database, we identified 207 displaced proximal humerus fractures that met all inclusion and exclusion criteria. For patients who accepted our invitation to return for evaluation, clinical outcome was assessed using several questionnaires: Constant; DASH (Disabilities of the Arm, Shoulder, and Hand); SMFA (Short Musculoskeletal Functional Assessment); and Patient Reported Outcomes Measurement Information System (PROMIS) Physical Function Computer Adaptive Test.

Of the 207 patients, 61 were managed operatively and 146 nonoperatively. Operative patients had lower rates of malunion but higher rates of complications, which included screw perforation, loss of fixation, infection, and secondary surgical procedures. Forty-seven patients (a mix of operative and nonoperative) accepted our invitation to return for clinical evaluation at a mean follow-up of 3.3 years. The 2 groups' clinical outcomes were similar.

Proximal humerus fractures are increasingly common in the elderly population,[1] accounting for 10% of all these patients' fractures.[2] The injuries result in substantial morbidity and are associated with significantly higher mortality rates for up to 4 years.[3] With the recent advent of anatomical locking plates,[4,5] operative fixation of proximal humerus fractures in elderly patients has become more common.[6] Although early clinical studies reported favorable outcomes, high complication rates have also been documented.[7-22]

Investigators have recently compared outcomes of locked plate fixation and nonoperative treatment of proximal humerus fractures in elderly patients.[23-26] Fjalestad and colleagues[23] conducted a randomized clinical trial of locked plating versus nonoperative treatment of 3- and 4-part fractures in 50 patients age 60 years or older and found no significant differences in Constant score or patient self-assessment at 1 year. Similarly, Olerud and colleagues[25] conducted a randomized clinical trial of locked plating versus nonoperative treatment of 3-part fractures in 60 patients age 55 years or older. Although outcomes were better in the operative group, differences did not reach statistical significance, and the operative group's reoperation rate was 30%.

Given this lack of conclusive outcomes data, optimal treatment of displaced proximal humerus fractures in elderly patients remains unknown. We conducted a study to compare outcomes of operative (locked plate fixation) and nonoperative management of displaced proximal humerus fractures in patients older than 60 years. Our hypothesis was that the clinical outcomes of these 2 treatment methods would be similar.

Materials and Methods

Selection Criteria

Our research protocol was approved by the Partners Human Research Committee. To determine the operative cohort, we queried our trauma database to identify all patients over age 60 years who sustained a displaced proximal humerus fracture between 2006 and 2009 and underwent surgical fixation. Cases were excluded if they presented more than 4 weeks after injury; if they represented a refracture, nonunion, or pathologic fracture; if the fracture was an isolated greater or lesser

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tuberosity fracture; if there was an associated neurovascular injury; if the injury radiographs were absent or inadequate; or if a fixation method other than locked plating was used. Applying these inclusion and exclusion criteria yielded 61 patients over age 60 years who underwent locked plating of a displaced proximal humerus fracture between 2006 and 2009.

The comparison group consisted of all patients who presented to our institutions with a displaced proximal humerus fracture during the same time period but instead had nonoperative treatment. To identify this group, we performed another database search for all patients over age 60 years who sustained a proximal humerus fracture between 2006 and 2009 (n = 452). Twenty-two patients were excluded for inadequate radiographs. To determine which of the other 430 patients had displaced fractures, Dr. Okike and Dr. Lee (orthopedic surgeons) reviewed injury radiographs and any computed tomography scans in duplicate and resolved discrepancies by consensus. Neer's criteria were used to define displacement: Fractures displaced 1 cm or more and/or with angulation of 45° or more were displaced, and fractures not meeting these criteria were nondisplaced. In the assessment of displacement, interobserver reliability was substantial (overall agreement, 87.0% [374/430]; $\kappa = 0.68$). With use of these methods, 311 fractures were classified displaced and 119 nondisplaced. As with the operative group, cases were excluded if they presented more than 4 weeks after injury; if they represented a refracture, nonunion, or pathologic fracture; if the fracture was an isolated greater or lesser tuberosity fracture; if there was an associated neurovascular injury; if injury radiographs were absent or inadequate; or if the treatment method was operative or unknown. Applying these inclusion and exclusion criteria yielded 146 patients over age 60 years who had nonoperative treatment of a displaced proximal humerus fracture between 2006 and 2009.

Patient Characteristics

Dr. Makanji retrospectively reviewed the charts of all 207 patients (61 operative, 146 nonoperative). Information was recorded on patient age and sex, mechanism of injury, number of days between injury and presentation, any associated orthopedic injuries, side of injury, and treatment facility (trauma center A, trauma center B). In addition, a Charlson score was assigned to each patient on the basis of medical comorbidities.[27]

Radiographs and any computed tomography scans were also assessed by Dr. Okike and Dr. Lee. Each fracture was assigned a Neer classification (2-part, 3-part, 4-part) and an AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association) classification (A, B, C).[28] Displacement was categorized as varus angulation (neck–shaft angle, <130°), valgus angulation (neck–shaft angle, >140°), neutral angulation (neck–shaft angle, 135° ± 5°), or translation alone. In addition, all fractures were assessed for dislocation and medial comminution.[29]

Outcome Measures

All follow-up radiographs were reviewed to assess for nonunion (defined as lack of healing by 12 months), malunion, and humeral head avascular necrosis. Operative patients' follow-up radiographs were reviewed to determine frequency of screw perforation and/or loss of fixation, and their medical records were reviewed to assess for other complications, including infection, neurovascular injury, and return to operating room for any other reason. Nonoperative patients' medical records were reviewed to determine if surgical treatment was subsequently required.

To determine clinical outcomes, we asked patients to return for clinical evaluation, which included use of several questionnaires: Constant; DASH (Disabilities of the Arm, Shoulder, and Hand); SMFA (Short Musculoskeletal Functional Assessment); and Patient Reported Outcomes Measurement Information System (PROMIS) Physical Function Computer Adaptive Test.

Statistical Analysis

Chi-square test was used to compare the characteristics of patients who returned for clinical evaluation, Fisher exact test was used for tables with multiple cells less than 5, Student *t* test was used to compare clinical outcomes between operative and nonoperative groups. $P < .05$ was considered statistically significant, and all tests were 2-sided. Statistical analysis was performed using SAS Version 9 (SAS, Cary, North Carolina).

Results

Of the 207 patients who met the inclusion and exclusion criteria, 61 were treated operatively (locked plate open reduction and internal fixation) and 146 nonoperatively. Mean age was 76.9 years. One hundred fifty-five (74.9%) of the patients were female. Medical comorbidities were common (average Charlson score, 6.6). Most patients (185/207; 89.4%) were injured in a fall. There were 129 two-part fractures, 63 three-part fractures, and 9 four-part fractures (**Table 1**).

Operative patients' complications included screw perforation (35.6%; 21 of the 59 cases with radiographs) and loss of fixation (17.5%; 10/57). Four (6.6%) of the 61 operative patients developed an infection. In sum, 8 (13.1%) of operative patients required another surgery (**Table 2**).

Among nonoperative patients, malunion at time of healing was common (86.9%; 113 of the 130 cases with radiographs). Eighty-six malunions (66.2% of the 130 cases) healed in varus, 25 (19.2%) in valgus, and 2 (1.5%) with translation alone. Uncommon among nonoperative patients were nonunion (1.4%; 2/143) and avascular necrosis (2.2%; 3/136). Two (1.4%) of the 146 nonoperative patients subsequently underwent surgery for malunion (**Table 2**).

Forty-seven patients accepted our invitation to return for clinical evaluation. Mean follow-up was 3.3 years (range, 1.4-6.4 years). Of these patients, 25 had been treated operatively (**Figures 1A, 1B**) and 22 nonoperatively (**Figures 2A, 2B**). Complication rates for patients who returned for clinical evaluation were similar to those for the entire cohort, with the exception of secondary surgical procedures (**Table 3**). There were no significant differences between operative and nonoperative patients in the group that returned for clinical evaluation (**Table 4**).

Table 1. Characteristics of Study Population and Proximal Humerus Fractures, All Patients

Characteristic	Treatment		
	Nonoperative	Operative (ORIF)	Overall
Patient-Related Factors			
Age, y			
60-69	21 (14.4%)	29 (47.5%)	50 (24.2%)
70-79	54 (37.0%)	15 (24.6%)	69 (33.3%)
80+	71 (48.6%)	17 (27.9%)	88 (42.5%)
Sex			
Female	109 (74.7%)	46 (75.4%)	155 (74.9%)
Male	37 (25.3%)	15 (24.6%)	52 (25.1%)
Charlson score			
≤3	4 (2.7%)	12 (19.7%)	16 (7.7%)
4-6	49 (33.6%)	26 (42.6%)	75 (36.2%)
≥7	74 (50.7%)	17 (27.9%)	91 (44.0%)
Unknown	19 (13.0%)	6 (9.8%)	25 (12.1%)
Mechanism of injury			
Fall	134 (91.8%)	51 (83.6%)	185 (89.4%)
Motor vehicle collision	3 (2.1%)	1 (1.6%)	4 (1.9%)
Pedestrian struck	4 (2.7%)	5 (8.2%)	9 (4.4%)
Other/unknown	5 (3.4%)	4 (6.6%)	9 (4.4%)
Days to presentation			
0	99 (67.8%)	39 (63.9%)	138 (66.7%)
1-7	40 (27.4%)	18 (29.5%)	58 (28.0%)
8-28	2 (1.4%)	3 (4.9%)	5 (2.4%)
Unknown	5 (3.4%)	1 (1.6%)	6 (2.9%)
Associated orthopedic injury			
Other orthopedic injury requiring surgery	17 (11.6%)	23 (37.7%)	40 (19.3%)
Other orthopedic injury not requiring surgery	20 (13.7%)	4 (6.6%)	24 (11.6%)
No associated orthopedic injury	109 (74.7%)	34 (55.7%)	143 (69.1%)
Fracture-Related Factors			
Neer classification[a]			
2-part	97 (66.4%)	32 (58.2%)	129 (64.2%)
3-part	43 (29.5%)	20 (36.4%)	63 (31.3%)
4-part	6 (4.1%)	3 (5.5%)	9 (4.5%)
AO/OTA classification[a]			
A	97 (66.4%)	32 (58.2%)	129 (64.2%)
B	40 (27.4%)	15 (27.3%)	55 (27.4%)
C	9 (6.2%)	8 (14.5%)	17 (8.5%)
Angulation			
Valgus	46 (31.5%)	11 (18.0%)	57 (27.5%)
Neutral	32 (21.9%)	8 (13.1%)	40 (19.3%)
Varus	56 (38.4%)	18 (29.5%)	74 (35.8%)
Translation	2 (1.4%)	12 (19.7%)	14 (6.8%)
Unknown/cannot be determined	10 (6.9%)	12 (19.7%)	22 (10.6%)
Dislocation[a]			
Yes	3 (2.0%)	9 (16.4%)	12 (6.0%)
No	143 (98.0%)	46 (83.6%)	189 (94.0%)
Medial comminution[a]			
Yes	73 (50.0%)	27 (49.1%)	100 (50.0%)
No	73 (50.0%)	28 (50.9%)	101 (50.0%)
Treatment Facility			
Trauma center A	54 (37.0%)	25 (41.0%)	79 (38.2%)
Trauma center B	92 (63.0%)	36 (59.0%)	128 (61.8%)
Total	**146 (100.0%)**	**61 (100.0%)**	**207 (100.0%)**

Abbreviations: AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association); ORIF, open reduction and internal fixation.

[a]Excludes fractures for which classification could not be determined.

Regarding clinical outcome scores, there were no significant differences between operative and nonoperative patients (**Table 5**). In particular, there were no differences in SMFA Functional index (18.4 vs 19.7; P = .78), SMFA Bothersome index (20.8 vs 23.6; P = .61), DASH scores (26.5 vs 25.1; P = .79), Constant scores (58.0 vs 59.7; P = .74), or PROMIS Physical Function Computer Adaptive Test scores (43.9 vs 45.0; P = .70).

Table 2. Complications of Nonoperative and Operative Treatment, All Patients

Complication[a]	Treatment	
	Nonoperative (n = 146)	Operative (ORIF) (n = 61)
Nonunion	1.4% (2/143)	0.0% (0/57)
Malunion at healing	86.9% (113/130)	40.0% (20/50)
Avascular necrosis	2.2% (3/136)	17.9% (10/56)
Infection	0.0% (0/146)	6.6% (4/61)
Iatrogenic neurovascular injury	0.0% (0/146)	0.0% (0/61)
Screw perforation	—	35.6% (21/59)
Loss of fixation	—	17.5% (10/57)
Secondary surgical procedure	1.4% (2/146)	13.1% (8/61)

Abbreviation: ORIF, open reduction and internal fixation.
[a]In each category, patients excluded if data unavailable.

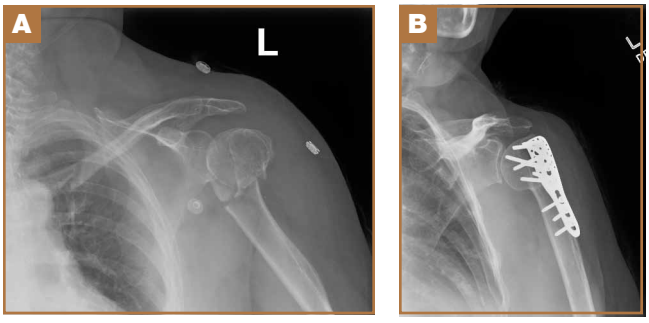

Figure 1. (A) Injury radiograph of 63-year-old woman who underwent operative treatment (locked plating) for 2-part proximal humerus fracture sustained in fall. (B) Radiograph 4 years after surgery; Constant score, 66.

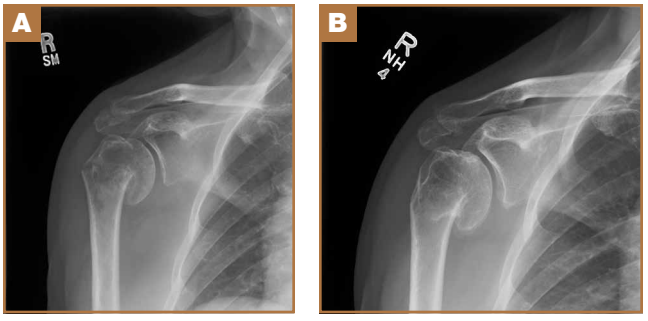

Figure 2. (A) Injury radiograph of 62-year-old man who underwent nonoperative treatment for 3-part proximal humerus fracture sustained in fall. (B) Radiograph 3.5 years after injury; Constant score, 66.

Discussion

In this observational study of displaced proximal humerus fractures in an elderly population, operative treatment (vs nonoperative treatment) had a lower malunion rate but was associated with more complications, including screw perforation, loss of fixation, and unplanned return to the operating room. Among patients who returned for clinical evaluation at a mean follow-up of 3.3 years, there were no significant operative–nonoperative differences.

Our results are similar to those recently reported by other investigators. In Norway, Fjalestad and colleagues[23] conducted a randomized controlled trial of locked plating versus nonoperative treatment in 50 patients over age 60 years with a 3- or 4-part proximal humerus fracture. At 12 months, there was no significant difference between the operative and nonoperative groups' Constant scores.

Similarly, Olerud and colleagues[25] in Sweden conducted a trial in which 60 patients over age 55 years with a 3-part fracture of the proximal humerus were randomized to locked plating or nonoperative treatment. At 2 years, there were no significant operative–nonoperative differences on several outcome measures: Constant scores, DASH scores, EQ-5D (EuroQol) scores. Thirty percent of operative patients required a secondary procedure to treat infection, nonunion, avascular necrosis, screw perforation, stiffness, or impingement.

Our study benefited from having a large sample size (207) of consecutive patients with displaced proximal humerus fractures, but it also had its limitations. In this retrospective study, treatment assignment was not randomized. We

Table 3. Complications of Nonoperative and Operative Treatment Among Patients Who Returned for Evaluation

Complication[a]	Treatment	
	Nonoperative (n = 22)	Operative (ORIF) (n = 25)
Nonunion	0.0% (0/21)	0.0% (0/22)
Malunion at healing	90.9% (20/22)	31.8% (7/22)
Avascular necrosis	0.0% (0/22)	17.4% (4/23)
Infection	0.0% (0/22)	4.0% (1/25)
Iatrogenic neurovascular injury	0.0% (0/22)	0.0% (0/25)
Screw perforation	—	36.0% (9/25)
Loss of fixation	—	16.0% (4/25)
Secondary surgical procedure	4.5% (1/22)	8.0% (2/25)

Abbreviation: ORIF, open reduction and internal fixation.
[a]In each category, patients excluded if data unavailable.

Table 4. Characteristics of Study Population and Proximal Humerus Fractures Among Patients Who Returned for Evaluation

Characteristic	Treatment			*P*
	Nonoperative	Operative (ORIF)	Overall	
Patient-Related Factors				
Age, y				.069
60-69	8 (36.4%)	17 (68.0%)	25 (53.2%)	
70-79	8 (36.4%)	6 (24.0%)	14 (29.8%)	
80+	6 (27.3%)	2 (8.0%)	8 (17.0%)	
Sex				.73
Female	13 (59.1%)	16 (64.0%)	29 (61.7%)	
Male	9 (40.9%)	9 (36.0%)	18 (38.3%)	
Charlson score				.068
≤3	3 (13.6%)	9 (36.0%)	12 (25.5%)	
4-6	10 (45.5%)	12 (48.0%)	22 (46.8%)	
≥7	8 (36.4%)	2 (8.0%)	10 (21.3%)	
Unknown	1 (4.6%)	2 (8.0%)	3 (6.4%)	
Mechanism of injury				.80
Fall	20 (90.9%)	21 (84.0%)	41 (87.2%)	
Motor vehicle collision	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Pedestrian struck	1 (4.6%)	1 (4.0%)	2 (4.3%)	
Other/unknown	1 (4.6%)	3 (12.0%)	4 (8.5%)	
Days to presentation				.15
0	15 (68.2%)	12 (48.0%)	27 (57.5%)	
1-7	6 (27.3%)	10 (40.0%)	16 (34.0%)	
8-28	0 (0.0%)	3 (12.0%)	3 (6.4%)	
Unknown	1 (4.6%)	0 (0.0%)	1 (2.1%)	
Associated orthopedic injury				.38
Other orthopedic injury requiring surgery	3 (13.6%)	8 (32.0%)	11 (23.4%)	
Other orthopedic injury not requiring surgery	1 (4.6%)	1 (4.0%)	2 (4.3%)	
No associated orthopedic injury	18 (81.8%)	16 (64.0%)	34 (72.3%)	
Fracture-Related Factors				
Neer classification[a]				.39
2-part	11 (50.0%)	13 (56.5%)	24 (53.3%)	
3-part	10 (45.5%)	7 (30.4%)	17 (37.8%)	
4-part	1 (4.6%)	3 (13.0%)	4 (8.9%)	
AO/OTA classification[a]				.40
A	11 (50.0%)	13 (56.5%)	24 (53.3%)	
B	9 (40.9%)	6 (26.1%)	15 (33.3%)	
C	2 (9.1%)	4 (17.4%)	6 (13.3%)	
Angulation[a]				.063
Valgus	8 (36.4%)	3 (15.0%)	11 (26.2%)	
Neutral	3 (13.6%)	2 (10.0%)	5 (11.9%)	
Varus	11 (50.0%)	10 (50.0%)	21 (50.0%)	
Translation	0 (0.0%)	5 (25.0%)	5 (11.9%)	
Dislocation[a]				.11
Yes	0 (0.0%)	4 (17.4%)	4 (8.9%)	
No	22 (100.0%)	19 (82.6%)	41 (91.1%)	
Medial comminution[a]				.29
Yes	7 (31.8%)	10 (43.5%)	17 (37.8%)	
No	15 (68.2%)	13 (56.5%)	28 (62.2%)	
Treatment Facility				**.80**
Trauma center A	8 (36.4%)	10 (40.0%)	18 (38.3%)	
Trauma center B	14 (63.6%)	15 (60.0%)	29 (61.7%)	
Total	**22 (100.0%)**	**25 (100.0%)**	**47 (100.0%)**	

Abbreviations: AO/OTA (Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association); ORIF, open reduction and internal fixation.

[a]Excludes fractures for which classification could not be determined.

Table 5. **Clinical Outcomes of Patients Who Returned for Evaluation**

Clinical Outcome Measure	Treatment, mean (SD)		
	Nonoperative	Operative (ORIF)	*P*
SMFA (Short Musculoskeletal Functional Assessment) Functional index	19.72 (17.0)	18.35 (15.4)	.78
SMFA Bothersome index	23.58 (17.4)	20.75 (19.7)	.61
DASH (Disabilities of the Arm, Shoulder, and Hand) score	25.08 (18.2)	26.49 (17.8)	.79
Constant score	59.69 (17.5)	57.96 (15.9)	.74
PROMIS (Patient Reported Outcomes Measurement Information System) Physical Function Computer Adaptive Test score	44.97 (10.5)	43.89 (8.5)	.70

Abbreviation: ORIF, open reduction and internal fixation.

were also limited by the large number of patients who did not return for clinical evaluation (160/207; 77.3%), including 52 (25.1%) found to be deceased, 27 (13.0%) who could not be reached, and 81 (39.1%) who declined our request (in many cases because of difficulties traveling to the trauma center). These challenges are inherent to research in the elderly population. As a result, the number of patients who returned for clinical evaluation (47/207; 22.7%) was lower than expected, which may have underpowered the study. In addition, treatment protocols were not standardized; patients were managed by a number of different surgeons. On the other hand, this wide variety of surgeons, including orthopedic trauma and upper extremity specialists, may increase the generalizability of our results.

Conclusion

Although use of locked plate fixation in treating proximal humerus fractures in elderly patients has increased markedly over recent years, definitive evidence supporting such management is lacking. In the present study, the outcomes of locked plate fixation were similar to those of nonoperative treatment. In addition, rates of complications and secondary surgical procedures were higher for operative patients than for nonoperative patients. Research is needed to identify the circumstances under which locked plating improves treatment outcomes for displaced proximal humerus fractures in elderly patients.

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