

Treatment Factors Associated with Humeral Shaft Fracture Nonunion

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INTRODUCTION:

Traditionally, most humeral shaft fractures can be managed non-operatively with high union rates with functional bracing developed by Sarmiento. However, union rates have been demonstrated as better with surgical management in certain studies. Often, the cause of fracture nonunion is multifactorial. Transverse displaced fractures and middle to distal third fractures of the humerus have been reported in literature with higher rates of nonunion. High age, infection, and comorbidities such as diabetes and osteoporosis have been documented and labelled as contributors. Furthermore, modifiable factors such as smoking, NSAID/corticosteroid use, and poor patient compliance have also been reported to contribute to worse outcomes. The aim of this study was to describe factors associated with risk of nonunion, and the characteristics and treatment of nonunion in patients treated for humeral shaft fracture in our patient population.

METHODS:

Adult patients treated for humeral shaft fracture at one Level 1 center from December 2009-July 2020, screened via ICD-10 code were retrospectively reviewed. Patient characteristics and radiographic analysis were recorded. Independent samples t-test was used for continuous variables, and chi squared or fishers exact test for categorical. $P < 0.05$ was considered significant.

RESULTS:

386 patients were included for analysis. 15.3% of patients went onto nonunion (mean time to diagnosis 122 days; Table 1). Patients with nonunion were more likely have comorbid alcoholism ($p < 0.001$) and hypothyroidism (0.048) and were significantly more likely to have been initially managed nonoperatively ($p < 0.001$; Table 2). Mechanism was significantly associated ($p 0.008$). Of those with nonunion treated surgically initially, there were differences in the number and positioning of screws utilized in ORIF, including more screws distally (4.29 ± 1.86 vs. 3.77 ± 0.92 , $p 0.048$) to the fracture, and fewer screws outside of the plate (0.41 ± 0.87 vs. 1.13 ± 1.44 , $p 0.045$) in diagnosed nonunion. 11 patients diagnosed with nonunion required more than 1 revision procedure (mean 2.18). 27 patients diagnosed with nonunion had available documented radiographic union (range 56-872 days from date of nonunion diagnosis).

DISCUSSION AND CONCLUSION:

Traditionally, nonoperative management was considered the standard of approach with humeral shaft fractures. Sarmiento et al. were able to demonstrate successful union rate of 97% for humeral fractures treated conservatively. However, more recently there have been studies that have challenged this with results favoring operative treatment.⁵ In our population this hypothesis holds true, demonstrating increased risk of nonunion with initial nonoperative management. Patient factors such as smoking and metabolic derangement have been linked to increased incidence of nonunion; in our population, alcoholism and hypothyroidism specifically were significant risk factors. Surgical technique additionally plays a role in nonunion risk; in our population, more screws distal to the area of fracture conferred increased risk of nonunion, which may have represented the working length of the construct utilized for fracture stabilization. Screws outside of the plate, typically utilized in lag screw fashion, confer decreased risk of nonunion, potentially informing meticulous surgical technique required for fracture reduction and compression across the fracture required for lag screw utilization. Nearly 19% of patients treated surgically for nonunion required more than one revision procedure, and risk of post-surgical infection more than doubled, demonstrating the patient morbidity associated with nonunion in this setting. Initial nonoperative management and configuration of the surgical construct in patients treated with ORIF are risk factors for development of humeral shaft fracture nonunion. Treatment and recovery from humeral shaft nonunion remain varied, warranting further study.

	Union:	Nonunion:	P value:
N	327 (84.7%)	59 (15.3%)	
Age (years)	56.21±7.22	59.83±7.171	0.233
Sex			0.264
Female	152 (46.3%)	32 (84.2%)	
Male	176 (53.7%)	27 (70.8%)	
BMI	29.26±7.81	29.54±8.5	0.819
Smoking			0.582
Current	76 (23.2%)	1 (30.5%)	
Former	37 (11.3%)	7 (11.9%)	
Never	178 (54.3%)	30 (80.8%)	
Occupation			0.699
Employed	76 (23.2%)	15 (25.4%)	
Unemployed	82 (25.0%)	21 (35.6%)	
IDDM	23 (7.0%)	3 (5.1%)	0.573
NIDDM	22 (6.7%)	5 (8.5%)	0.644
Dialysis	3 (0.9%)	0 (0%)	0.458
Alcoholism	10 (3.0%)	8 (13.6%)	<0.001
Osteoporosis	11 (3.4%)	1 (1.7%)	0.425
Hypothyroidism	36 (11.0%)	1 (20.3%)	0.048
ASA			0.37
1	16 (4.9%)	2 (3.4%)	
2	100 (30.5%)	22 (37.3%)	
3	65 (19.8%)	21 (35.6%)	
4	6 (1.8%)	0 (0%)	
5	2 (0.6%)	0 (0%)	
Mechanism			0.008
Low energy	146 (44.5%)	38 (65.5%)	
High energy	171 (52.1%)	20 (34.5%)	
GSW	11 (3.4%)	0 (0%)	
Additional Fractures			0.207
Ipsilateral upper extremity	20 (6.1%)	1 (1.7%)	
Contralateral upper extremity	14 (4.2%)	3 (5.1%)	
Lower extremity/pelvis	46 (14%)	8 (13.6%)	
Spine	15 (4.5%)	4 (8.5%)	
Open Fracture	35 (10.7%)	6 (10.2%)	0.908
Associated injury			0.191
None	297 (91.1%)	55 (93.2%)	
Abdominal injury	13 (4.0%)	1 (1.7%)	
Chest injury	12 (3.7%)	2 (3.4%)	
Head injury	9 (2.7%)	1 (1.7%)	

	Union:	Nonunion:	P value:
Initial treatment			<0.001
Operative	193 (58.8%)	17 (28.8%)	
Nonoperative	135 (41.2%)	42 (71.2%)	
Type of surgery			0.724
ORIF	193 (58.8%)	17 (28.8%)	
IMN	9 (2.7%)	0	
MPO	4 (1.2%)	0	
RSA w/ long stem	1 (0.3%)	0	
Approach			0.227
Anterior	107 (32.6%)	12 (20.3%)	
Posterior	86 (26.2%)	5 (8.5%)	
AO Classification			-
11A2	1 (0.3%)	0	
12A1	73 (22.3%)	12 (20.3%)	
12A2	44 (13.4%)	6 (10.2%)	
12A3	81 (24.7%)	13 (22%)	
12B1	26 (7.9%)	4 (6.8%)	
12B2	54 (16.5%)	13 (22%)	
12B3	13 (4.0%)	3 (5.1%)	
12C1	3 (0.9%)	1 (1.7%)	
12C2	12 (3.7%)	2 (3.4%)	
12C3	15 (4.6%)	4 (6.8%)	
13A2	1 (0.3%)	0 (0%)	
13A3	2 (0.6%)	1 (1.7%)	
Fracture location:			0.289
Proximal	69 (21.2%)	15 (25.4%)	
Middle	156 (47.9%)	34 (57.6%)	
Distal	98 (30.1%)	10 (16.9%)	
Complications:			-
Radial nerve injury after injury	40 (12.5%)	10 (17%)	
Radial nerve injury after surgery	1 (0.3%)	1 (1.7%)	
Infection with surgery	5 (1.5%)	2 (3.4%)	
Infection without surgery	2 (0.6%)	0 (0%)	
Death	2 (0.6%)	0 (0%)	
Malunion	5 (1.5%)	0 (0%)	
Adhesive capsulitis	1 (0.3%)	0 (0%)	
Compartment Syndrome	1 (0.3%)	0 (0%)	
Subsequent fracture/hardware failure	8 (2.4%)	7 (11.9%)	
Elbow contracture	1 (0.3%)	0 (0%)	
Time to last follow up (days)	206.49±316.82	414.53±395.46	