

Incidence and Functional Outcomes of Malunion of Nonoperatively Treated Humeral Shaft Fractures

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Abstract

We conducted a study to determine the overall incidence and long-term clinical and functional outcomes of patients with malunion after nonoperative management of humeral shaft fractures. Fifteen patients with radiographic malunion ($>20^\circ$ angulation or shortening of ≥ 2.5 cm) were identified, and their medical records retrospectively reviewed for information about their injuries and treatment. Long-term outcomes were assessed with a self-reported questionnaire, the DASH (Disabilities of the Arm, Shoulder, and Hand) form, and physical examination.

Of 91 study-eligible patients, 15 (16%) had malunion after nonoperative management of humeral shaft fractures treated over an 11.5-year period. The 8 patients reached for long-term follow-up had a mean DASH score of 10.4. Seventy-five percent of patients reported having no functional limitations and being satisfied with the outcome of their treatment. However, 75% also reported a noticeable cosmetic deformity; for 25% of patients, this was a major reason for dissatisfaction.

Our findings suggest that malunion may be more common than previously thought but, for a majority of patients, does not cause significant pain, functional limitations, or dissatisfaction. However, patients should be counseled about the high likelihood of cosmetic deformity, which they may find bothersome.

Humeral shaft fractures account for about 1% of all fractures.¹ With the exception of the few absolute indications for surgical intervention, such as the presence of an open fracture, the current teaching on treatment of these fractures is that the majority can be successfully managed nonoperatively.¹⁻³ These conservative measures consist of bandages, abduction splints, U-casts, hanging arm casts, and, most commonly, functional bracing, which is considered the gold standard for treatment of humeral shaft fractures by

many authors.¹⁻³ One of the most often cited disadvantages of nonoperative management over surgical treatment is the higher incidence of residual deformity, the most common of which is varus angulation.⁴

The incidence of malunion ($>20^\circ$ of angulation in any plane or shortening of ≥ 2.5 cm) after nonoperative treatment varies in the literature from 0% to 13%,^{2,4-9} with a recent literature review documenting a mean incidence of 4.4% within the frontal plane and 2% within the sagittal plane across all studies.² As reported initially by Sarmiento and colleagues^{3,9} and echoed by other authors,^{2,5,8} angular deformity of less than 20° is thought to be both cosmetically and functionally acceptable. Whether angular deformities or malunion of more than 20° actually leads to functional limitations is unknown. Although some observational reports suggest that the degree of radiographic malalignment does not necessarily correlate with functional outcome,⁸ no studies have specifically evaluated patient outcomes of humeral shaft fracture malunions.

We conducted a study to determine the overall incidence and long-term clinical and functional outcomes of patients with malunion after nonoperative management of humeral shaft fractures. Long-term outcomes were assessed with current symptoms, physical examination findings, need for subsequent operative intervention, DASH (Disabilities of the Arm, Shoulder, and Hand) scores, and a self-reported questionnaire. We hypothesized that patients who develop a malunion after nonoperative treatment of a closed humeral shaft fracture will have satisfactory functional outcomes based on subjective reports, physical examination findings, and DASH scores.

Methods

After obtaining institutional review board approval for the study, we selected patients from a retrospective medical record review of all those 18 years or older with a humeral shaft fracture managed nonoperatively at our institution between January 1, 2001, and June 30, 2012, with a minimum 1-year follow-up. We identified 156 patients with nonoperatively managed midshaft humerus fractures. Study exclusion criteria included fracture associated with a tumor (3 patients), ipsilateral upper extremity injury (9), open/ballistic injury (18), nonunion

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(9), underlying cognitive disability or psychiatric illness (4), and insufficient follow-up to clinical or radiographic healing (22). Ninety-one patients were eligible for study inclusion. Radiographs at time of final clinical visit were reviewed to assess for evidence of malunion at the fracture site, as defined by previously reported criteria³ (>20° angulation in anterior/posterior or varus/valgus plane of motion or shortening of ≥2.5 cm). Fifteen patients met all the inclusion criteria for further evaluation.

Medical records were retrospectively reviewed for information on age at injury, sex, comorbidities (eg, diabetes, osteoporosis, smoking), body mass index, type and duration of immobilization, complications, return to work, cosmetic perception, time to final clinical follow-up, and symptoms at final clinical follow-up. Incidence of potential risk factors associated with malunion—obesity, noncompliance, and comorbidities such as smoking and diabetes—was compared between the

15 patients with malunion and the other study patients, who healed without malunion.

For long-term postoperative follow-up, patients were contacted to be seen in clinic to complete an updated physical examination, self-reported questionnaire, and the DASH form. Physical examination included measurements of range of motion (ROM) and strength involving the shoulder, elbow, and forearm, with ROM reported as the difference between the injured and contralateral upper extremities. Neurovascular status and focal tenderness to palpation were also assessed on examination. When in-person examination was not possible, the questionnaire and DASH form were completed over the telephone. The self-reported questionnaire asked for information on smoking status, pain, functional limitations, cosmetic perception, satisfaction, and whether or not the patient would still opt for nonoperative management if presented with the same injury again. Pain and satisfaction were measured on numerical scales: Pain scores ranged from 0 (no pain) to 10 (worst possible pain), and satisfaction scores ranged from 1 (not satisfied) to 5 (very satisfied). Data are presented as mean values.

Table 1. Patients With Humeral Shaft Malunion

Patient No.	Age, y	Sex	Comorbidities	Type and Duration of Immobilization (wk)	Malunion
1	33	M	None	Coaptation splint (1.5) Fracture brace (10.5)	35.5° varus
2	41	F	None	Sling (12)	5 cm short
3	40	F	None	Posterior splint (2) Fracture brace (10)	22° varus
4	76	F	Osteoporosis Diabetes mellitus	Coaptation splint (0.5) Fracture brace (12.5)	3 cm short
5 ^a	79	M	Alcoholism	Coaptation splint (2) Fracture brace (6)	31° varus
6	35	M	None	Coaptation splint (1.5) Fracture brace (10.5)	22° varus
7	20	M	Smoker	Coaptation splint (0.5) Fracture brace (7)	20.5° varus
8	47	F	None	Coaptation splint (2) Fracture brace (7)	23° varus
9 ^b	33	M	None	Coaptation splint (1) Fracture brace (7)	23° varus
10 ^b	28	F	None	Coaptation splint (1) Fracture brace (12)	21° varus
11 ^b	62	M	None	Coaptation splint (1) Fracture brace (10)	20.5° varus
12 ^b	26	F	Smoker	Coaptation splint (1) Fracture brace (5)	27° varus
13 ^b	21	F	Smoker	Coaptation splint (1.5) Fracture brace (9.5)	25° varus
14 ^b	24	F	None	Coaptation splint (1) Fracture brace (9)	22° varus
15 ^b	20	M	Smoker	Hanging arm cast (1) Fracture brace (6)	21.5° varus

^aPatient 5 had the only complication (skin breakdown).

^bCould not be contacted for long-term follow-up.

Results

Of the 91 study-eligible patients, 15 (16%) met the radiographic criteria for the diagnosis of malunion. Retrospective data were available for all 15 patients from time of injury to final clinical follow-up (mean, 19 weeks; range, 7-53 weeks). Mean age at injury was 39 years (range, 20-79 years). Additional demographics are listed in **Table 1**. Incidence of potential risk factors, such as body mass index (26.5 vs 25.4), smoking (33% vs 33%), and diabetes (0% vs 8%), was not significantly different between the malunion and healed-without-malunion groups, respectively. Furthermore, all malunion patients were compliant with their treatment protocol.

Radiographs were assessed at time of final follow-up to confirm healing and to document malunion. Varus malunion was found in 13 patients (mean, 24°; range, 20.5°-35.5°), and shortening was documented in the other 2 patients (mean, 4 cm; range, 3-5 cm). Patients were immobilized a mean of 10 weeks (range, 6-13 weeks). Initial fracture management consisted of coaptation splinting for 1 to 2 weeks (12 patients), hanging arm cast for 1 week (1 patient), and posterior splint for 1 week (1 patient). Patients were then transitioned to Sarmiento fracture bracing for the duration of their treatment (range, 5-12 months). One patient, followed initially at an outside institution, was managed in a sling throughout the duration of treatment (12 weeks) (**Table 1**). All 15 patients were neurovascularly intact at time of final clinical examination, with return of full upper extremity ROM in all but 3 patients. Only 1 of these

3 patients reported residual pain and functional limitations 4 months after injury (Table 2). Twelve patients were evaluated for return to work, with all successfully returning to work without restrictions at time of final follow-up. The 1 minor complication noted during the treatment period involved medial-sided elbow skin breakdown from brace wear, which resolved with local wound care. No patient required or requested surgical intervention for their residual malunion.

Of the 15 patients, 8 (53%) were reached for in-person examination (6 patients) or telephone interview (2 patients) for follow-up assessment by means of DASH form and self-reported questionnaire a mean of 47 months (range, 12-99 months) after initial injury. The 6 patients who had a physical examination were neurovascularly intact, lacked focal tenderness to palpation, and demonstrated full (5/5) strength within the deltoid, biceps, triceps, pronator, and supinator musculature. Each patient had equal ROM compared with the contralateral uninjured extremity on shoulder forward flexion and abduction, elbow flexion and extension, and forearm pronation and supination. Three patients (50%) had mild residual loss of ROM, with 2 demonstrating decreased shoulder external rotation of 10° and 15°, respectively, and 1 demonstrating decreased shoulder internal rotation of 10°.

Mean DASH score was 10.4 (range, 0-49.2). Evaluation of the self-reported questionnaire revealed a mean pain score of 1.1 (range, 0-7), with only 2 patients reporting any ongoing pain. In addition, 2 patients reported functional limitations, both related to overhead activities. However, 6 (75%) of the 8 patients reported noticeable cosmetic deformity, most commonly varus angulation (4 patients), as well as palpable bony prominence (2) and muscle atrophy (1). The majority of patients were satisfied with the outcome of their treatment (mean, 4; range, 2-5), with 6 patients reporting being satisfied

or very satisfied, and all 6 indicating they would undergo non-operative management again if presented with the same injury. Two patients reported being dissatisfied with their outcome, 1 because of cosmetic appearance and 1 because of cosmetic appearance and functional limitations. Both patients indicated they would choose operative management if presented with the same injury. There was no apparent relationship between outcome and degree of residual deformity, as both patients with varus angulation of more than 30° reported no residual pain or functional limitation and were very satisfied with the outcome of their treatment (Table 2).

Of the 7 patients who could not be reached for final follow-up, 2 on initial contact expressed overall satisfaction with their outcome and denied functional limitations. However, both asked to complete the study at a later date. Subsequently, these 2 patients could not be reached to complete the formal follow-up.

Discussion

Humeral shaft fractures are usually managed nonoperatively. One of the most commonly cited disadvantages of nonoperative management is its higher incidence of residual angular deformity, up to 13% in previous studies.⁴ Our study found a slightly higher incidence, 16%, on review of 91 nonoperatively managed humeral shaft fractures treated over an 11.5 year period. Although previous studies have reported acceptable functional and cosmetic outcomes with residual angular deformity of less than 20°,^{2,3,5,8,9} only observational reports have suggested acceptable function in patients with a documented malunion.⁸

To our knowledge, ours is the first study to correlate malunion with functional parameters and subjective patient-reported outcomes. We found that malunion was not associated with significant pain or functional limitation after nonop-

Table 2. Patient Outcomes of Humeral Shaft Fracture Malunion

Patient No.	Time From Injury, mo	Decreased Range of Motion	DASH Score	Pain	Functional Limitation	Perceived Deformity	Satisfaction	Choose Surgery
1	77	15° external rotation	0	0	None	Varus angulation	5	No
2	18	10° internal rotation	20.8	2	None	None	4	No
3	86	None	11.7	0	Overhead activities	Bony prominence	2	Yes
4	25	None	0	0	None	Atrophy	5	No
5	41	10° external rotation	0	0	None	Varus angulation	5	No
6	12	None	0.8	0	None	Varus angulation	4	No
7 ^a	99	N/A	0.8	0	None	None	5	No
8 ^{a,b}	15	N/A	49.2	7	Overhead activities	Varus angulation, bony prominence	2	Yes
Mean	47	—	10.4	1.1	—	—	4	—

Abbreviations: DASH, Disabilities of the Arm, Shoulder, and Hand; N/A, not applicable.

^aTelephone interview only.

^bPatient had pain and decreased function at final clinical follow-up (4 months).

erative management of humeral shaft fractures. Furthermore, 75% of patients were satisfied or very satisfied with the outcome of their treatment and indicated they would undergo nonoperative management if presented with the same injury again. However, 75% of patients reported a noticeable cosmetic deformity, and one-third of these patients cited it as a major reason for dissatisfaction with their overall outcome. Regarding function, all patients returned to full strength and ROM of the affected extremity, aside from small losses of internal or external shoulder rotation on the magnitude of 10° to 15° in 50% of those patients tested. In addition, 75% of patients returned to regular activity without functional limitations; the other 25% reported trouble with overhead activities. There were no significant complications during the treatment or follow-up period, once the fracture had healed.

The major limitation of this study was its small patient population. (Obtaining a larger series of patients with malunion after nonoperative treatment of humeral shaft fractures likely would require a multicenter study.) Some of our study findings, such as lack of correlation between degree of malunion and subsequent functional or subjective outcomes, would require a larger sample size for verification and more definitive conclusions. Another limitation is that the study was not designed to evaluate the cause of malunion. Therefore, we cannot draw any definitive conclusions regarding what may have contributed to the development of malunion in our study population. However, all our malunion patients were compliant with their treatment protocol, and they showed no significant difference in incidence of potential risk factors (eg, obesity, comorbidities) compared with the patients who healed without malunion.

Conclusion

Malunion after nonoperative management of humeral shaft fractures does not appear to result in significant pain, dissatisfaction, or functional limitation as measured on physical examination and with validated objective outcome measures in the majority of patients. Furthermore, no patients in this study required surgical intervention for any residual limitations or complications after malunion. The majority of patients reported a noticeable cosmetic deformity, which left a small subset of patients dissatisfied. Overall, our study findings can

be used to help counsel patients before and during nonoperative management—particularly patients who appear to be healing with some malunion. Our findings suggest that operative intervention to prevent malunion is not necessary, as it likely would not result in any overall improvement in patient function or satisfaction, but patients should be counseled regarding the high likelihood of cosmetic deformity, which may or may not be bothersome.

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This paper will be judged for the Resident Writer's Award.
