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Factors predicting patient-reported functional outcome scores after humeral shaft fractures☆

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ABSTRACT

Purpose: The aim of this study was to determine patient variables that are independent predictors of validated functional outcome scores after humeral diaphyseal fractures.

Methods: Adult patients with humeral shaft fractures were retrospectively recruited from a level 1 trauma centre over an 8-year period. Basic demographic information was obtained along with Disabilities of the Arm, Shoulder and Hand (DASH), Simple Shoulder Test (SST) and Short Form 12 (SF-12) physical component summary (PCS) and mental component summary (MCS). Regression analysis was performed to identify patient factors associated with satisfactory outcomes, defined as DASH < 21; SST ≥ 10; PCS ≥ 40; and MCS ≥ 40. Of 95 eligible patients, 77 were recruited. Participants had an average age of 47 ± 20 years. Forty-five patients were treated with surgery and 32 healed non-operatively. The average follow-up was 48 ± 29 months.

Results: Satisfactory DASH scores decreased with increase in age (odds ratio (OR) 0.95; $P = 0.023$). Satisfactory SST scores were more likely in patients without a history of psychiatric illness (OR 6.3; $P = 0.01$). Satisfactory SF-12 PCS scores were more likely with no psychiatric history (OR 12; $P = 0.007$) and in patients with private insurance (OR 11.4; $P = 0.03$), but these scores decreased with rising Charlson comorbidity index (CCI; OR 0.50; $P = 0.023$). Satisfactory SF-12 MCS scores increased in the absence of psychiatric history (OR 39; $P = 0.003$), and decreased with rising CCI score (OR 0.54; $P = 0.035$). Analysis of patients younger than 50 years of age ($n = 38$) revealed that the absence of psychiatric history increased the odds of satisfactory DASH scores (OR 10.4; $P = 0.04$). Patients aged ≥ 50 ($n = 39$) had worse DASH scores with increasing age (OR 0.89; $P = 0.037$), better SST scores with middle-third fractures compared to proximal (OR 7.8; $P = 0.039$), better SF-12 PCS with no psychiatric history (OR 16.1; $P = 0.018$) and worse scores with rising CCI (OR 0.50; $P = 0.036$), while rising CCI decreased the odds of satisfactory SF-12 MCS scores (OR 0.47; $P = 0.046$). Treatment modality, associated fractures and classification as "high energy" mechanism were not associated with outcome.

Conclusion: Patient age, history of psychiatric illness, insurance type, fracture location and Charlson comorbidity index scores had a statistically significant effect on patient-reported functional outcomes following treatment of humeral shaft fractures, regardless of treatment modality, injury mechanism and associated fractures. The impact of these variables may be age dependent.

Introduction

Fractures of the humeral diaphysis account for roughly 1–5% of all fractures [1] and follow a characteristic bimodal age distribution [2]. Most of these fractures are treated without surgery [1], provided they meet the following accepted criteria: alignment with $<20^\circ$ of angulation in the anterior–posterior plane, $<30^\circ$ of varus–valgus angulation, $<15^\circ$ of malrotation and <3 cm of shortening [3]. Open reduction with internal fixation may be performed for open fractures, vascular injury, articular extension, polytrauma, floating elbow, progressive radial nerve deficits, brachial plexus injury, significant soft tissue injuries prohibiting bracing, pathologic fractures and failed non-operative management [1].

Many studies previously published on outcomes after humeral shaft fractures have focused on quantitative measures, such as non-union rates, radial nerve deficits, varus/valgus malunion and

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range of motion [4–8]. Functional outcome measures tend to be more qualitative, and they take into account the patient's ability to perform everyday tasks. As validated functional outcome scores have become the standard for assessing outcomes after injury, it becomes important to identify patient factors that independently influence these outcome scores.

The purpose of this study was to report functional outcomes of patients who underwent treatment of humeral shaft fractures at a level 1 trauma centre, and to use regression analysis to identify independent patient factors that are associated with a patient's likelihood of a satisfactory outcome. We hypothesise that increasing age, history of psychiatric illness and high-energy trauma will be predictors of worse functional outcomes.

Methods

Billing records between 2004 and 2012 were reviewed to identify patients with humeral shaft fractures at a level 1 trauma centre. The inclusion criteria for this study included adult patients (age $\geq$18) at the time of fracture, minimum of 1-year follow-up at the time of study evaluation, and up-to-date contact information in our medical centre's electronic health record. Patients were excluded for the following reasons: unavailable contact information (n = 52), age (n = 38), deceased (n = 23), the fracture predominantly affecting the metaphysis or epiphysis (n = 19), new injury or surgery of the affected extremity unrelated to the initial trauma (n = 5), advanced dementia (n = 2), non-English speaker (n = 2), significant brain or spinal cord injuries (n = 2) and brachial plexus injury (n = 1). Based on the selection criteria, 95 patients were eligible for participation, and they were recruited by telephone to obtain the following functional outcome scores: Disabilities of the Arm, Shoulder and Hand (DASH), the Simple Shoulder Test (SST), and general health questionnaire Short Form-12 (SF-12), which included a physical component summary (PCS) and mental component summary (MCS). Of this cohort, six refused to participate, and 12 could not be reached with the available contact information after multiple attempts. A total of 77 patients (81%; 77/95) were successfully recruited. The average age of study participants at the time of injury was 47 $\pm$ 20 years (range 18–87), with an average follow-up of 48 $\pm$ 29 months. Forty-five patients were definitively treated with surgery. The group demographics are presented in Table 1.

Patient chart reviews were conducted to obtain basic demographic data, including patient age at the time of fracture, time from injury or surgery to interview, Charlson comorbidity index (CCI) score, presence of workers' compensation claims and presence of any psychiatric medical comorbidity. The aetiology of the fracture was determined with chart review and by phone interview.

Forty-five of the patients who were recruited had undergone surgical fixation. Efforts were taken to treat all patients non-operatively, unless one or more of the following indications for surgery were present: open fractures, vascular injury, articular extension of fracture, polytrauma, floating elbow, progressive radial nerve deficits, brachial plexus injury, significant soft tissue injuries prohibiting bracing, pathologic fractures, morbid obesity, non-union and patient inability to tolerate non-operative treatment. Within the surgical group there were four patients who failed non-operative treatment (non-union) and underwent definitive treatment with surgical fixation at an average of 9.5 months after their initial injury. Operative treatment consisted of open reduction and internal fixation using plates and screws for all fractures except one, which was treated with intramedullary nailing (IMN). There was a mix of 4.5-mm limited contact dynamic compression (LCDC) plates, 3.5-mm plates, and long proximal humeral locking plates, depending on the fracture location within the diaphysis. An anterior approach was used in 38 cases, a posterior approach in six and a deltoid splitting approach for IMN in one.

Non-operative treatment consisted of coaptation splinting for roughly 2 weeks. When the patient no longer had tenderness on application of pressure at the fracture site, functional bracing was initiated and independent active range-of-motion exercises were encouraged. As healing progressed, resistive strengthening exercises and passive stretching were initiated. All patients were cared for by one of four fellowship-trained orthopaedic traumatologists at some point during their care.

Based on previous reports of population averages and minimal clinically important differences (MCIDs), patients were classified as having a satisfactory outcome if their DASH was <21, SST $\geq$ 10, SF-12 PCS $\geq$ 40 and SF-12 MCS $\geq$ 40 [9–16]. We limited our analysis to 12 variables: [17] age, follow-up length, surgical versus non-operative treatment, body mass index (BMI), presence of associated fractures, fracture location (proximal, middle and distal third), radial nerve palsy, smoking status, CCI score, insurance type, classification as high-energy mechanism and history of psychiatric illness.

After an analysis was performed on the entire cohort, the patients were divided into two groups, based on age (group 1 age <50 (n = 38); group 2 age $\geq$50 (n = 39)). Because the group sizes were substantially decreased, we only analysed seven variables: age, surgical versus non-operative treatment, presence of associated fractures, fracture location, CCI, classification as high-energy mechanism and history of psychiatric illness. The group demographics are presented in Table 1.

Table 1
Basic group variables. All presented as average $\pm$ standard deviation.

General group characteristics	All patients (N = 77)	Patients' age <50 (N = 38)	Patients' age $\geq$50 (N = 39)	P-value (<50 vs. $\geq$50)
Age (years)	47 $\pm$ 20	30 $\pm$ 10	64 $\pm$ 11	<0.001**
Follow-up (months)	48 $\pm$ 29	48 $\pm$ 28	47 $\pm$ 31	0.84
Surgical treatment	N = 45	N = 20	N = 25	0.31
BMI	29 $\pm$ 7	30 $\pm$ 8	29 $\pm$ 7	0.58
High-energy mechanism	N = 38	N = 23	N = 15	0.052
Associated fracture	N = 25	N = 13	N = 12	0.75
Presence of psychiatric history*	N = 23	N = 9	N = 14	0.24
Radial nerve palsy present at time of Injury	N = 14	N = 7	N = 7	0.99
Charlson comorbidity score	0.75 $\pm$ 1.7	0.1 $\pm$ 0.3	1.4 $\pm$ 2	<0.001**
DASH	19 $\pm$ 20	16 $\pm$ 16	22 $\pm$ 23	0.17
SST	9.1 $\pm$ 3.4	9.9 $\pm$ 2.9	8.4 $\pm$ 3.4	0.03**
SF-12 PCS	44 $\pm$ 12	47 $\pm$ 11	42 $\pm$ 12	0.09
SF-12 MCS	52 $\pm$ 11	53 $\pm$ 10	51 $\pm$ 11	0.64

* All patients with a history of psychiatric illness reported depression, depression and anxiety, or bipolar disorder.
** Denotes $P < 0.05$.