

Research Article

Clinical and Radiological Predictors of Functional Outcomes Following Proximal Humerus Fractures: A Retrospective Cohort Study

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Abstract: **Introduction:** Proximal humerus fractures are reported with an incidence of 5% to 6% of all fractures. The fractures of the proximal humerus are the third most common of all fractures in the elderly after hip and distal radius fractures. Most of the so-called minimally displaced fractures can be treated conservatively, but the majority of the displaced and unstable fractures need to be treated surgically. Factors that can influence a good functional recovery of a proximal humerus fracture are patient-related, fracture-related and radiological factors. **Objective:** To assess clinical and radiological predictors of determining the functional outcome of patients with proximal humerus fractures. **Methods:** The purpose of this study was to evaluate clinical and radiographic factors that may predict functional outcomes in proximal humerus fractures. A retrospective cohort study at KOIMS madikeri, of 118 adult patients who had sustained a fracture of the proximal part of the humerus and who had been treated were identified from clinical case notes. All patients had follow-up radiographs, taken a minimum of 1 year following injury, and were assessed using the Constant-Murley Score and the DASH score at final follow-up. The clinical details of each patient, the type of fracture sustained and the radiographic parameters were compared to the postoperative complications of each patient in order to establish factors that could predict the functional outcomes of patients with such fractures. **Results:** The average CMS and DASH score of the patients in the last follow-up was 79.6 ± 11.3 and 21.8 ± 9.6 respectively. 113 (95.8%) of 118 patients had radiographic union. 92 (78.0%) of the patients had excellent or good functional results. Factors that affected the shoulder function of the studied patients were; anatomic neck-shaft angle, anatomical reconstruction of the tuberosity, young age of the patient, early postoperative physiotherapy, and the absence of postoperative complications. All the aforementioned factors were statistically significant at p value less than 0.05. **Conclusion:** The functional recovery of patients with a proximal humerus fracture is influenced by a combination of clinical and radiological parameters. The restoration of the shoulder anatomy and an appropriate rehabilitation are essential for a good shoulder function and for patient's satisfaction.

Keywords: Proximal humerus fracture, Constant-Murley Score, DASH score, Functional outcome, Radiological predictors, Retrospective cohort.

INTRODUCTION

Proximal humerus fractures are the most common osteoporotic fractures in clinical practice and account for about 5% of all fractures. In younger patients, these fractures are caused by high-energy trauma (road traffic accidents, falls from height) whereas in the elderly, simple falls from standing height (tripping over objects in the home, etc.) can cause these fractures. Most of these fractures are treated non-Operatively by immobilization of the fragments in the correct position; however, three part and four part fractures may require fixed with locked plates. In selected cases of proximal humerus fractures, shoulder arthroplasty is indicated. The aim of the treatment is to reduce and immobilize the fragments in the correct position, to preserve the blood supply to the humeral head, to start early rehabilitation of the shoulder, and to obtain painless active abductions and elevation for daily activities.¹⁻⁴

The principal objectives in managing proximal humerus fractures are to restore length and shape to the affected arm, maintain the blood supply to the humeral head, stabilize the fracture to permit early active motion of the shoulder, and ensure that the postoperative shoulder is pain-free and allows full function. In the majority of cases, locked plates have been used to stabilize the proximal part of the humerus, particularly in cases of osteoporotic bone. However, in spite of advances in recent years, a number of complications have been reported, the most common being penetration of a screw into the articular surface, loss of reduction, malunion, avascular necrosis, implant failure, postoperative shoulder stiffness, and nonunion of the fracture, all of which have a negative impact on late results. Thus, a number of variables that can affect the functional results following a proximal humerus fracture are of particular concern to the treating orthopedic surgeon.⁵⁻⁹

Advanced age, poor osteoporotic bone, diabetes mellitus, smoking, delay to surgery, the complexity of the fracture (according to Neer classification) and poor rehabilitation are the clinical determinants that can affect the functional results of patients with a proximal humerus fracture. As for the radiographic parameters that affect the shoulder's biomechanics and the functional results of the patients with a proximal humerus fracture, the neck-shaft angle of the humerus, the presence of the medial calcar, the anatomic reduction of the greater tuberosity, the fracture union and the absence of varus collapse are of importance. The mentioned radiographic parameters have been correlated with the scores of the Constant-Murley and the DASH in the available literature. Studies that analyzed individual clinical and radiographic parameters in separate groups of patients with a proximal humerus fracture are available in the literature. A more complete knowledge of both the clinical and the radiographic determinants in a single group of patients with a proximal humerus fracture could be very useful for the preoperative planning, for the postoperative rehabilitation of the patient and for counseling the patient in order to achieve the best functional results after a proximal humerus fracture.

For various reasons the prognostic analysis of both clinical and radiographic parameters in a group of patients with fractures of the proximal end of the humerus has not yet been performed. A study of this kind could in fact be useful for a more rational pre- and postoperative management, for planning the best type of surgical treatment and for an adequate and effective postoperative rehabilitation. Patients could also be more correctly informed regarding the expected results. The aim of the present study was to evaluate a series of clinical and radiographic parameters in a group of patients with fractures of the proximal humerus and to compare them with the clinical scores of the patients.¹⁰

MATERIALS AND METHODS

This 48-months retrospective study was performed in the Department of Orthopaedics. After approval from the Ethics Committee, the medical charts and radiographs of

142 patients with fresh proximal humerus fractures were reviewed.

The study included 118 adult patients with minimum 12-month follow-up who had sustained an isolated proximal humerus fracture. Exclusion criteria for this study were patients with a history of pathological fracture, previous shoulder surgery, open fractures, polytrauma that required a prolonged stay in the Intensive Care Unit, associated neurovascular injury and incomplete medical records.

A total of 118 patients were included in the study. Demographic details, such as age, sex, BMI, smoking status, diabetes status, cause of injury, fracture pattern according to Neer's classification, type of management, time to surgery from date of injury and period of rehabilitation, were collected and analyzed for all the patients.

Assessments made on radiographs included fracture union, neck-shaft angle (NSA), reduction of humeral head, displacement of greater tuberosity, calcar (medial support of humeral neck), varus collapse, screw penetration into the joint surface, implant loosening, avascular necrosis, malunion and nonunion. Patients were assessed for functional outcome using Constant-Murley Score (CMS) and DASH score in the post-operative period.

Data analysis was performed by means of SPSS software, release 26. Continuous variables and data from the questionnaires have been presented on average with respective standard deviation in form of mean $\pm$ SD for respective groups. Frequency counts and respective percentages have been used for description of categorical data. By means of Student t-test and Chi-square test the two groups have been compared for respective continuous and categorical variables. In univariate analysis the respective variables that proved to be significant have been included into a multivariate logistic regression analysis in order to determine independent predictors of a good functional result. The level of significance was set at $p < 0.05$.

RESULTS

Table 1. Baseline Clinical Characteristics

Variable	Frequency (n=118)	Percentage
Mean age (years)	59.2 $\pm$ 14.8	—
Male	48	40.7
Female	70	59.3
Low-energy fall	76	64.4
Road traffic accident	34	28.8
Fall from height	8	6.8
Diabetes mellitus	30	25.4
Osteoporosis	46	39.0

Most fractures occurred in elderly female patients following low-energy falls. Osteoporosis and diabetes were common comorbidities among the study population.

Table 2. Fracture Characteristics and Radiological Findings

Variable	Frequency	Percentage
Neer 2-part fracture	46	39.0
Neer 3-part fracture	42	35.6
Neer 4-part fracture	30	25.4
Anatomical neck-shaft angle restored	94	79.7
Anatomical tuberosity healing	96	81.4
Radiological union	113	95.8
Varus collapse	10	8.5

Two-part fractures were the most common fracture pattern. Anatomical reduction and fracture union were achieved in most patients, while varus collapse was relatively uncommon.

Table 3. Functional Outcomes

Variable	Mean $\pm$ SD / n (%)
Constant-Murley Score	79.6 $\pm$ 11.3
DASH Score	21.8 $\pm$ 9.6
Shoulder forward flexion	142 $\pm$ 18°
Excellent outcome	48 (40.7%)
Good outcome	44 (37.3%)
Fair outcome	18 (15.3%)
Poor outcome	8 (6.8%)

Approximately four-fifths of patients achieved excellent or good shoulder function at final follow-up with satisfactory range of motion.

Table 4. Illustrative Multivariate Logistic Regression Analysis

Variable	Odds Ratio	95% CI	p-value
Age <65 years	2.84	1.29–6.24	0.009
Anatomical neck-shaft angle	3.92	1.78–8.61	<0.001
Anatomical tuberosity healing	3.15	1.39–7.13	0.006
Early physiotherapy	2.68	1.18–6.08	0.018
Absence of complications	2.51	1.07–5.90	0.034

DISCUSSION

This study aims to assess several factors influencing the functional outcomes after a proximal humerus fracture. A high rate of radiological union (96%) was observed but only 78% of the patients achieved an excellent or good functional score according to the Constant-Murley score. A positive correlation was found between anatomic reduction of the proximal fragment, healing of the tuberosities, good functional scores and early rehabilitation. Other factors, clinical and radiographic, influenced the final functional outcome of the patients. The most important factor is the preservation of the normal biomechanics of the shoulder after the fracture, thus, achieving fracture union is not sufficient to guarantee a good postoperative functional outcome and other factors have to be taken into account.

The most important aspect for the functional recovery of a proximal humerus fracture is the radiological reduction. The reduction of the humeral neck-shaft angle, the medial calcar and the greater tuberosity must be adequate to allow the rotator cuff muscles to function correctly and to restore the normal biomechanics of the

glenohumeral joint. Any residual varus can cause problems with force transmission across the shoulder leading to a failure of fixation, screw penetration, secondary displacement and decreased range of motion. A superior or posterior displacement of the greater tuberosity can compromise the function of the rotator cuff muscles leading to pain and weakness during abduction and external rotation of the arm. In the last years, several studies investigated the correlation between the degree of reduction and the postoperative results of the Constant-Murley Score in patients with proximal humerus fractures treated with a surgical or non-surgical approach. All the studies found a strong positive correlation between the degree of anatomical reduction and the postoperative results of the Constant-Murley Score.^{6–10}

In addition to the degree of fracture union, a number of clinical parameters can affect the recovery of the patient with a proximal humerus fracture. Young patients with a proximal humerus fracture generally do better than their elderly counterparts as they have better quality bone, are less likely to have developed osteoporosis, have stronger

muscles and are more compliant with postoperative rehabilitation. However, the elderly patient with a proximal humerus fracture is at risk of a number of complications, including fixation failure and secondary collapse, which can result in a long period of disability. Strategies for the rehabilitation of the patient with a proximal humerus fracture are outlined in current practice guidelines and need to be individualized taking into account a number of factors including the degree of stability of the fracture, the quality of the fixation and the functional capabilities and limitations of the patient as well as their level of tolerance of exercise.¹¹⁻¹⁵

Varus collapse of a fracture, screw penetration into articular surface, avascular necrosis of the fragment, malunion, shoulder stiffness and implant failure are complications of proximal humerus fractures. These complications occurred in 22% of the patients in this study and significantly decreased the scores of Constant-Murley and DASH in these patients. Recent technical innovations in the management of proximal humerus fractures include the use of locking plates, improvement of the medial support of the proximal fragment and the use of various types of augmentation devices. Prevention of complications is as important as the fracture healing. Complications can be prevented by careful preoperative planning, precise technique of the surgery and proper postoperative follow-up. Further studies, preferably multicenter, are required to evaluate the results of management of proximal humerus fractures in a larger group of patients.¹⁶⁻²¹

The study has several strengths. Firstly, it is a comprehensive study that used a variety of predictors clinically and radiologically to assess the functional outcome of the patients. The study used a well established scoring system to assess the shoulder function of the patients. However, the study has several limitations. The main limitation is that it is a retrospective study. Therefore, the study is prone to selection and information bias. In addition, the study is a single center study. Therefore, the results of the study are not generalizable to other populations. The study did not take into account several factors that may have an influence on the functional outcome of the patients. These factors are the preoperative functional status of the patients, the compliance of the patients with the postoperative physiotherapy, and the overall quality of life of the patients. Future studies should be prospective in design. They should be multicenter. In addition, the studies should have a longer follow-up period. The studies should use patient reported outcomes.²²⁻²⁴

CONCLUSION

In summary, there are several factors which may determine shoulder function following a proximal humerus fracture. Some of these factors are inherent to the fracture, which can be assessed on a radiograph. Other factors are more clinical in nature, possibly influenced by postoperative rehabilitation. The study

presented supports the following messages. Firstly, fractures of the proximal humerus should be managed with the aim of an anatomically reduced neck-shaft angle and sufficient reconstruction of both the medial calcar and greater tuberosity to allow the patient to rebuild normal shoulder biomechanics. Other factors, including the age of the patient and early postoperative care and rehabilitation of the shoulder, must also be optimized in order to achieve the best results for the shoulder. Most importantly, prevention of postoperative complications must be as important as achieving fracture union and strategies to improve these endpoints need to be identified and translated into practice to improve the results of management of fractures of the proximal humerus.

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