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Clinical and radiologic results of open reduction and fixation with locked plate screws in proximal humerus fracture–dislocation

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Abstract

Aim: Proximal fracture dislocations of the humerus are rarely seen in society compared to other fractures. In our study, we evaluated the clinical and radiological results of patients who underwent open reduction and locked plate–screw fixation with proximal humerus fracture–dislocation. Material and Method: Between January 2009 and January 2016, 17 patients were treated with open reduction and locking plate screws in the Department of Orthopedics and Traumatology at the Faculty of Medicine, Dicle University. Patients were divided into two groups according to age. Group 1 consisted of 6 patients over 65 years of age and the mean age was 77.5 (69-87). Group 2 consisted of 11 patients under 65 years of age and the mean age was 41.6 (24-60). Group 1 consisted of all female patients and Group 2 consisted of all male patients. Patient fractures were classified according to the Neer classification. Oxford Shoulder Scale, DASH Score, and Constant Murley Score were used in the clinical evaluation of the patients. Avascular necrosis phase was performed according to Cruess phase. Results: The mean follow-up period of the patients was 13.8 months (range 10-38). The mean duration of surgery was 1.11 days (range 0-4). According to the Neer classification, 11.8% of the cases were two-part fracture dislocation, 64.7% were three-part fracture dislocation, and 23.5% were four-part fracture dislocation. There was a statistically significant difference between Oxford and DASH scores in the clinical outcome according to age groups (p = 0.001, p=0.049). Avascular necrosis was observed in 14 of 17 (82.3%) patients. Additional complications such as wound infection, nonunion were not observed. Discussion: In proximal humerus fracture–dislocations, the first surgical choice should be open reduction and internal fixation in young patients, whereas internal fixation in addition to arthroplasty should be considered in elderly patients.

Keywords

Humerus; Fracture; Avascular Necrosis; Open Reduction; Plate

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Introduction

Fracture–dislocations of the proximal humerus constitute 5% of proximal humerus fractures and 0.25% of all fractures. Proximal humerus fracture is the third most prevalent fracture after hip and distal radius fractures in elderly patients aged >65 years [1]. These fractures are rarely seen together with dislocations. Proximal humerus fracture–dislocations usually occur in young people as a result of high-energy injuries. However, in older age groups they mostly occur after simple trauma because of underlying senile osteoporosis. Usually, Neer [2] and AO (Arbeitsgemeinschaft für Osteosynthesefragen) classifications are used in the classification of proximal humerus fracture–dislocations.

Proximal fractures of the humerus are usually treated conservatively [3]. In cases with accompanying dislocation, on the other hand, surgical intervention is required [4]. The main goal in surgical treatment is to ensure that the patient returns to daily activities as soon as possible by choosing a method that results in the least disruption of blood circulation, least damage to the surrounding soft tissue, earliest restoration of patient's mobility, and earliest stabilisation of the patient's status. Although adequate reduction and stabilisation can be achieved with open reduction and internal fixation, prosthetic implantation may be an additional treatment option, especially in elderly patients. The reported complications include cut-out or back-out of the screws and plates, avascular necrosis (AVN) of the humeral head, malunion, nonunion, rotator cuff impairment, impingement syndrome, and nail migration [5,6].

In this study, we evaluated clinical and radiological results of the patients who underwent surgical stabilisation of the fracture with open reduction and plate–screw fixation after the diagnosis of fracture–dislocation of the proximal humerus.

Material and Method

A total of 25 patients who presented between January 2009 and January 2016 with traumatic fracture–dislocation of the shoulder and were treated with open reduction and internal fixation with plate and screw were included in the study (Figures 1 and 2). Eight patients were excluded from the study; of those, three died and five were lost during follow-up. Seventeen extremities of the remaining 17 patients were evaluated with history, physical examination, and radiological examinations (Table 1). Pathological fracture–dislocations and pediatric fracture–dislocations were not included in the study.

Six of the patients were female (35.2%) and 11 (64.8%) were male. The mean age was 54.2 years (range 24–87 years). Eight patients had fracture–dislocation in the right shoulder and nine patients in the left shoulder. The cases were divided into two groups according to age. Group 1 included patients aged ≥ 65 years and Group 2 included patients aged < 65 years. Group 1 consisted of 35.2% of patients who all were female. The mean age was 77.5 (69–87) years. Group 2 consisted of 64.8% of all patients who were all male. The mean age was 41.6 (24–60) years. Because of the accompanying acetabular fracture, one patient underwent surgical fixation of acetabular fracture using open reduction and plate–screw fixation in the same session.

Figure 1. 52-year-old male (case 5) with an anterior three-part fracture dislocation, fixed with a plate (a) pre-operative AP X-ray, (b) post- operative AP X-ray (c) last control AP X-ray (d) final control shoulder abduction and internal rotation motion span

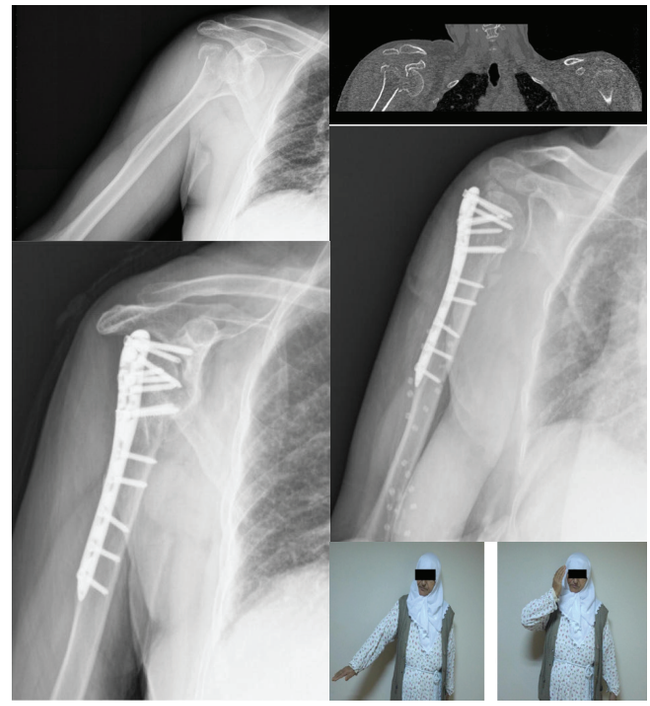


Figure 2. 73-year-old female (case 1) with an anterior four-part fracture dislocation, fixed with a plate (a) pre-operative AP X-ray, (b) pre-operative coronal CT image (c) post- operative AP X-ray (d) last control AP X-ray (e) final control shoulder abduction and external rotation motion span

According to the Neer classification, 11.8% cases (2 patients) had two-part fracture–dislocation, 64.7% cases (11 patients) had three-part fracture–dislocation, and 23.5% cases (4 patients) had four-part fracture–dislocation. In terms of dislocation direction, 17.6% cases (3 cases) had posterior dislocation and 82.4% cases (14 cases) had anterior dislocation (Table 2). The cause of fracture–dislocation in the patients was simple fall in 47.1% cases, motor vehicle accident in 41.2% cases, and epileptic seizure in 11.8% cases.

Table 1. Patient information table included in the study

Patient no	Age	gender	Trauma type	Trauma date	Operation date	Time between trauma and surgery (days)	side	fracture type(Neer clasification)	hospital stay (days)	Follow-up time (month)	Additional injury	oxford score	DASH score	Constant Morley score	Cruess score (avascular necrosis)
1	73	F	SF	06.05.2012	07.05.2012	1	R	4-part AD	4	12	no	46	55,2	14	5
2	77	F	SF	12.05.2009	13.05.2009	1	R	3-part AD	3	12	no	36	48,2	62	4
3	36	M	MVA	12.11.2010	13.11.2010	1	L	3-part PD	4	10	no	19	4,4	84	0
4	87	F	SF	29.06.2009	30.06.2009	1	R	3-part AD	3	10	no	40	51,6	56	4
5	52	M	SF	30.09.2009	01.10.2009	1	L	3-part AD	6	11	no	13	0,9	97	4
6	85	F	SF	16.04.2013	17.04.2013	1	R	3-part AD	2	13	no	33	46,4	30	3
7	45	M	MVA	17.06.2011	18.06.2011	1	L	2-part PD	3	12	no	32	35,8	33	5
8	43	M	MVA	31.08.2012	31.08.2012	0	R	2-part AD	4	38	no	41	51,7	14	5
9	50	M	SF	30.09.2015	03.10.2015	3	R	4-part AD	6	15	no	20	6,3	56	3
10	60	M	MVA	18.12.2010	22.12.2010	4	L	4-part AD	5	10	no	25	23,3	68	2
11	69	F	SF	22.03.2013	23.03.2013	1	L	3-part AD	7	23	no	32	49,1	33	5
12	34	M	MVA	01.03.2012	02.03.2012	1	L	3-part AD	7	12	left acetabulum fracture	25	26,2	58	3
13	74	F	SF	14.02.2009	15.02.2009	1	L	3-part AD	5	10	no	48	60,3	12	4
14	24	M	ES	07.09.2015	08.09.2015	1	R	3-part AD	2	15	no	14	3,4	73	0
15	32	M	ES	11.12.2015	12.12.2015	1	L	3-part AD	3	10	no	28	36,1	60	0
16	40	M	MVA	16.11.2015	16.11.2015	0	L	3-part AD	3	10	no	32	38,4	30	3
17	42	M	MVA	18.12.2015	18.12.2015	0	R	4-part PD	4	12	no	37	52,8	23	3

ES: Epileptic seizure SF: Simple fall MVA: Motor vehicle accident R: Right L: Left AD: Anterior dislocation PD: Posterior dislocation

Table 2. Percentage distribution of broken pieces and dislocation direction according to Neer Classification

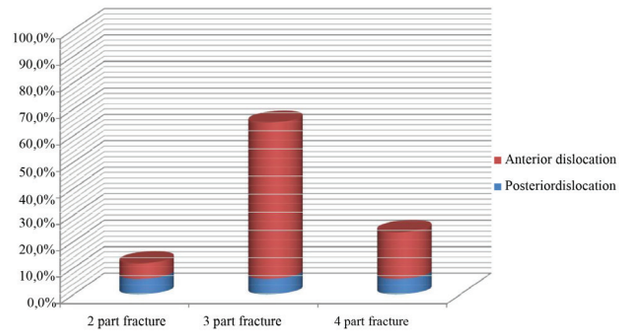
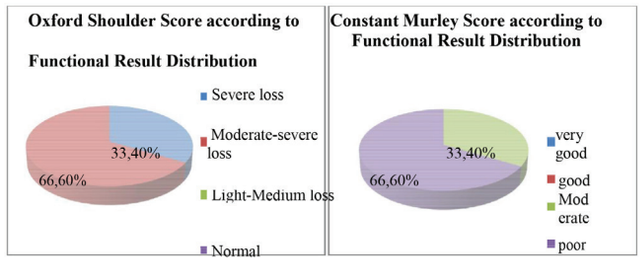


Table 3. Percent distribution of functional outcomes according to Oxford Shoulder Score and Constant Murley Score in Group 1



Surgical Techniques

The patients were operated on in a modified supine position under general anaesthesia. The deltopectoral approach was used. The joint capsule was opened and humeral head and fractured fragments were reduced without damaging the soft tissue. In cases with posterior dislocation, the humeral head was reduced without using a metal retractor but using digital manipulation. Fragments were fixated with temporary K-wires or bone clamps. A proximal humerus anatomical locking plate

Table 4. Percentage distribution of functional results according to Oxford Shoulder Score and Constant Murley Score in Group 2

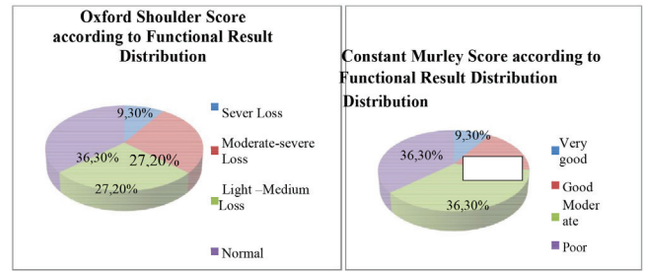
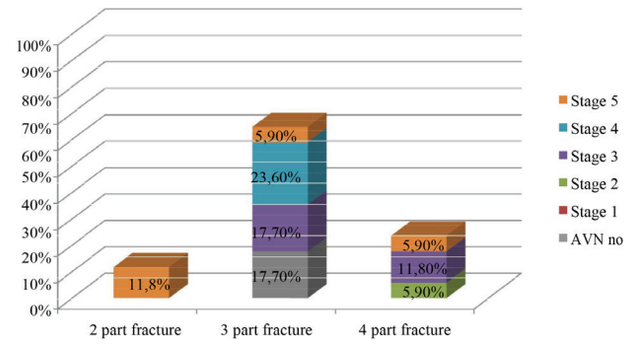


Table 5. Statistical value table between AVN phase and functional shoulder scores of cases

		Oxford score	DASH score	Constant Murley Score
AVN	r	0,586	0,464	-5,32
Stage	p	0,013	0,061	0,028

Table 6. AVN percentage distribution graph according to number of broken pieces



was placed lateral to the bicipital groove in order to avoid tendon entrapment during abduction. After verification of the plate position under fluoroscopic control, the locking screws were inserted into the head, under fluoroscopy guidance. ensuring they did not enter the joint space. Then the locking screws were inserted distally. No drain was used.

The shoulder was immobilised postoperatively. Passive mobilisation was performed five days after the operation, taking into consideration the strength of stabilisation, patient's age, and bone quality.

In the radiological assessment, nonunion, AVN, and presence of osteoarthritis were evaluated. The Cruess classification system was used to evaluate patients for AVN. The Oxford Shoulder Score, the DASH (Disabilities of the Arm, Shoulder and Hand) score, and the Constant Murley Score were used for functional assessment [7, 8].

Statistical Evaluation

The statistical analysis of the data in this study was performed using SPSS version 21 (Statistical Package for the Social Sciences) software. All our assessments were performed within a 95% confidence interval. The significance level for all tests was set to 0.05. The data were analysed by the Shapiro–Wilk test to determine whether or not they showed normal distribution, and it was accepted that the data were normally distributed for the groups with $p > 0.05$. According to the normality test results, the data were analysed by the parametric Student t-test, or Kruskal–Wallis, Mann–Whitney U-test, and Spearman rank correlation tests, which are nonparametric. Descriptive statistics were used to summarise the demographic data.

Results

The mean duration from trauma to operation was 1.11 days (0–4 days). The mean duration of hospitalisation was 4.17 days (2–7 days), and the mean follow-up time was 13.8 months (range 10–38 months).

In radiological evaluation, there was AVN of humeral head in 14 (82.3%) out of 17 cases. According to the Cruess classification, AVN of humeral head at different stages had developed in all patients in Group 1. The distribution of the cases was that Stage-5 AVN was observed in two cases (33.3%), Stage-4 AVN in three cases (50.3%) and Stage-3 AVN in one case (16.7%). In one patient with Stage 5 (73 years old), Stage-4 AVN was observed in the 12th month postoperative radiograph; removal of the implant and hemiarthroplasty was recommended but the patient refused surgery. In the follow-up, two screws in the humeral head of the patient began to contact the glenoid articular surface and AVN progressed to Stage 5. There was AVN in eight (72.7%) of 11 cases in Group 2. The distribution of the cases was that Stage-5 AVN was observed in two cases (18.1%), Stage-4 AVN in one case (9.09%), Stage-3 AVN in four cases (36.3%), and Stage-2 AVN in one case (9.09%) (Figure 3). Implant extraction surgery was performed on two patients with Stage-5 AVN (45 years, 43 years), in the 10th (45 years) and 30th (43 years) follow-up months upon patient request. The patients had Stage-5 AVN when they were operated on. When the relationship between age and AVN stage was examined using the Spearman rank correlation test, a correlation of 55% was found between these two variables and it is statistically significant in favour of Group 2 ($p = 0.022 < 0.05$).

When the functional results of Group 1 were examined, the mean Oxford Shoulder Score was 39.16 points (range 32–48). Four cases (66.6%) had moderate-severe loss of shoulder function and two cases (33.4%) had severe loss of shoulder function. The mean Constant Murley Score was 34.5 points (range 12–62). Two cases (33.4%) had a moderate functional result and four cases (66.6%) had a poor functional result (Table 3). The mean DASH score was 52.34 (46.4–60.3).

When the functional results of Group 2 were examined, the mean Oxford Shoulder Score was 26 (13–41) points. Four cases (36.3%) had normal shoulder function, three cases (27.2%) had mild to moderate loss of shoulder function, three cases (27.2%) had moderate to severe loss of shoulder function, and one case (9.3%) had severe loss of shoulder function. The mean Constant Murley Score was 54.18 (range 14–97). One case (9.3%) had a very good functional result, two cases (18.1%) had a good functional result, four cases (36.3%) had a moderate functional result, and four cases (36.3%) had a poor functional result (Table 4). The mean DASH score was 20.9 (0.9–52.8).

According to age groups, the difference between the mean Oxford Shoulder Score and the mean Constant Murley Score was analysed by the Student t-test. In the comparison between the groups, the Oxford Score showed a significant difference in favour of Group 2 ($p = 0.001 < 0.05$), whereas there was no significant difference in the Constant Murley Score ($p = 0.136 > 0.05$). In the comparison performed by the Mann–Whitney U-test, the DASH score was significantly higher in Group 2 ($p = 0.049 < 0.05$).

As age increases, there is also an increase in the AVN stage. The Oxford Shoulder Score and the DASH score were significantly correlated with the age groups; the correlation was lower in Group 1, which consisted of patients aged >65 years and it was higher in Group 2, which consisted of patients aged <65 years. The Constant Murley Score did not correlate with the age groups.

When the relationship between shoulder function scores and AVN levels of the patients was analysed by the Spearman rank correlation test, a statistically significant correlation was found between the AVN level and the Oxford Shoulder Score ($p = 0.013 < 0.05$) and the Constant Murley Score ($p = 0.028 < 0.05$). There was no statistically significant correlation between the AVN stage and the DASH score, but p values were close to statistical significance ($p = 0.061 > 0.05$; Table 5). According to the number of fractured pieces, the AVN distribution was 100% (two cases, both had Stage-5 AVN) in two-part fractures, 72.72% (one case had Stage-5 AVN, four cases had Stage-4 AVN, three cases had Stage-3 AVN and three cases did not have AVN) in three-part fractures, and 100% (one case had Stage-5 AVN, two cases had Stage-3 AVN, one case had Stage-2 AVN) in four-part fractures (Table 6). The relationship between the number of fractured pieces and AVN stage could not be assessed because the data groups would not provide a satisfactory result as they were not adequate in the Chi-Square test.

When the cases were evaluated in terms of complications, nonunion, surgical site problems, infection and neurovascular injury were not observed.

Discussion

In proximal humerus fractures, anatomical reduction and stable fixation is necessary. Biomechanical investigations showed that fixation strength increased after use of locking plates [9, 10]. The PHILOS locking plate system provides anatomical reduction and angular stability in osteoporotic bone. This facilitates early extremity movement, which improves shoulder function while minimising postoperative complications [11, 12]. Our purpose in this study is to reveal functional results of treatment of fracture–dislocations of proximal humerus by locking plate, especially between different age groups.

The outcomes of treatment for proximal humerus fractures using locking plates show great variability [13-15]. In the study conducted by Ye et al. [16], 89 patients with three- or four-part proximal humerus fractures were treated by locking plate; the complication rate during >1 years follow-up period was 20.2%. The complications included screw breakage, AVN of humeral head, back-out of the screws off the humeral head, subacromial impingement, malunion, and tubercle resorption. Complication risk is usually associated with advanced age, bone quality, fracture pattern, loss of reduction, loosening or breakage of implants and AVN (avascular necrosis). According to Konrad [17] and Ruchholtz [18], 40% of complications arise from inappropriate surgical techniques and the complication rate is associated with the surgeon's experience. In multicentre prospective studies, Sudkamp et al. [19] and Brunner et al. [20] showed that when performed with correct surgical techniques, treatment with locking plates is associated with good functional results. In these studies, although complication rates for the implant are high, DASH and Constant Murley functional results are good.

AVN is a complication that can be seen in proximal humerus fractures and is associated with fracture severity. The rate of development of AVN after four-part proximal humerus fractures is 21%–75% [21, 22]. Hertel et al. [23] stated that AVN can be observed in up to 97% cases with calcar length <8 mm, displaced anatomical head fracture, and disruption in the structure of medial hinge. In our study, AVN was observed in all our patients aged >65 years. AVN was observed in 72.7% patients aged <65 years. In a series of 39 patients with four-part fracture–dislocation treated with open reduction and internal fixation, Soliman et al. [24] reported an AVN rate of 20.51%, but all the cases in this study were reported to be aged <40 years. Trupka et al. [25] reported that in three- and four-part displaced fractures, the presence of dislocation increased the AVN rate and poor functional outcomes only in the elderly population. The cases in our study showed parallel results; it was observed that the AVN rate increased and functional scores decreased with increasing patient age. The relationship between the number of fractured parts and AVN could not be assessed because the principle of statistical adequacy was not met.

In a study conducted on 82 patients with fracture and fracture–dislocation of the proximal humerus, Erasmo et al. [26] showed that functional loss is greater in patients with advanced-stage AVN. When the statistical relationship between AVN stage and functional scores was evaluated in our study, a statistical correlation was found between the Oxford Shoulder Score, the Constant Murley Score, and the AVN stage, although there was no correlation with DASH score although p values were close to statistical significance.

In their study, Khurana et al. [27] evaluated hemiarthroplasty versus internal fixation in terms of functional outcomes in patients with four-part proximal humerus fractures and there was no significant difference between the two groups. In a study by Chen et al., they compared functional outcomes of intramedullary fibula allograft with LCP with hemiarthroplasty in patients with four-part proximal humerus fractures; they reported superior outcomes in the LCP group. In another study, Bonneviella et al. [28] evaluated hemiarthroplasty versus reverse shoulder prosthesis on four-part proximal humerus fractures in terms of functional outcomes; they found reverse shoulder prosthesis superior to hemiarthroplasty. Another subject emphasised in this study is that arthroplasty is suggested in the treatment of humeral fractures only after failure of internal fixation procedure [28].

The main weaknesses of our study are as follows. First, the number of cases was low because fracture dislocations of the shoulder are rare traumatic events. Second, the procedures were performed by different surgeons, although a standard surgical procedure was used. Third, the follow-up period was relatively short, there was no randomisation among patients, and there was no control group. There is a need for multicentre, prospective, randomised and comparative studies where the groups are homogeneous and the number of patients is high so that more accurate results can be obtained.

Conclusion

In our study, although AVN rates in patients with fracture–dislocation of the shoulder who underwent open reduction and internal fixation with locking plates were high, the functional outcomes were better in younger patients than in older patients. In proximal humerus fracture–dislocations, the first surgical choice should be open reduction and internal fixation in young patients, whereas internal fixation in addition to arthroplasty should be considered in elderly patients.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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