Shoulder hemiarthroplasty for revision of complex proximal humeral fractures fixed with K-wires in patients above 50 years of age

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Background
Displaced comminuted proximal humeral fractures are severe injuries. Operative treatment with retention of the humeral head includes closed or open reduction and external or internal fixation with wires, nails, or plates. We present a series of category 1 patients treated with hemiarthroplasty after failed wire fixation of complex proximal humeral fractures.
Patients and methods
Twelve patients with category 1 fracture sequelae of the proximal humerus were treated with hemiarthroplasty. The mean age was 60 years. These complex fractures were initially fixed with K-wires; thereafter, closed reduction was performed in four patients and open reduction in eight patients. The complications that led to revision surgery were malreduction, dislocation, nonunion, and avascular necrosis. The average time lapse from the initial surgery was 7.92 months.
Results
The mean follow-up was 22.25 months. At 18-month follow-up, the active forward elevation increased from 44.42 to 116.25° and the Constant score improved from 20.58 to 66.17. Shoulder hemiarthroplasty for failed initial surgery was successful in category 1 fracture sequelae, but the results were inferior to those reported after primary hemiarthroplasty.
Conclusion
This should be taken into consideration when choosing a line of treatment for complex fractures of the proximal humerus in the elderly population.

Keywords:
fractures, proximal humerus, shoulder hemiarthroplasty

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Introduction

Displaced comminuted proximal humeral fractures are severe injuries [1]. Operative treatment with retention of the humeral head includes closed or open reduction and external or internal fixation with wires, nails, or plates [2].

The reported results of fixation of these complex fractures are variable, with many complications including inadequate reduction, poor fixation and loss of reduction, malunion, nonunion, avascular necrosis (AVN), pain, stiffness, infection, and late arthritis [3–5].

A few studies have reported that late arthroplasty is technically more difficult and is associated with more complications and worse functional outcome compared with acute humeral head replacement [6,7]. Most of these studies included patients with malunion, osteonecrosis, nonunions, and late arthritis in the same series; in addition, the type of arthroplasty was not standardized. Boileau *et al.* [8] classified late fracture sequelae into four types and distinguished them into two categories.

The purpose of this study was to present a series of category 1 patients treated with hemiarthroplasty after failed wire fixation of complex proximal humeral fractures and to evaluate the results.

Patients and methods

From 2009 to 2011, 12 patients underwent shoulder hemiarthroplasty for treatment of fracture sequelae after failed primary fixation with K-wires; all patients had the initial surgery performed in other hospitals.

There were eight women and four men. The mean age of patients at the time of revision surgery was 60 years (range 51–72). The initial classification according to Neer [9] was three-part fracture in five patients, four-part fracture in one patient, query 3/4 fracture in three patients, three-part fracture dislocation in one patient, and four-part fracture dislocation in two patients.

The initial surgery was performed through closed reduction in four patients, open deltopectoral approach in six patients, and open superior approach in two patients. The K-wires were protruding from the skin in

nine patients (four closed and five open) and were not protruding in three patients. The complications that led to revision of the initial surgery were malreduction of the initial fracture or dislocation in three patients, nonunion in three patients, and AVN and nonunion in six patients. Only one patient had pin-track infection. The time interval between the initial surgery and hemiarthroplasty had a mean of 7.92 months (range 2–12) (Table 1).

Patients were evaluated according to the Constant score [10]. Subjective pain score had a mean of 4.58 preoperatively (range 0–10), and activities of daily living (ADL) had a mean of 4.67 (range 2–6). Objective range of motion (ROM) had a mean score of 6.33 (range 2–10) and the strength (lbs) had a mean of 5 (range 4–7). The active forward elevation had a mean of 44.2° (range 35–65). The preoperative Constant score had a mean of 20.58 (range 13–29).

All patients were evaluated radiographically with radiographs (anteroposterior in scapular plane and lateral scapular views) as well as with computed tomographic scan including three-dimensional reconstructions. Computed tomographic scans were used to assess the viability of the head and the condition of the rotator cuff muscles. No patients were diagnosed with massive rotator cuff tears preoperatively or with advanced fatty degeneration (Goutallier stage 3 or 4) of the rotator cuff muscles [11].

Surgical technique

All patients underwent operative treatment by the author (O.A.S.), using the same prosthesis and the same surgical technique. A standard deltopectoral approach was used in 10 patients. A superior approach was used in two patients who had a prior open reduction through a superior approach. All patients were category 1 with intracapsular collapse or AVN (type 1) or dislocations (type 2). The operation was performed in one stage in 11 patients. In the patient who had pin-track infection, the operation was performed in two stages; an initial debridement was performed and the head was removed in the first stage, intravenous antibiotics were administered, and the prosthesis was implanted after 6 weeks when the C-reactive protein returned to normal levels.

Osteotomy of the greater tuberosity was performed in two patients who did not have a previous fracture of the greater tuberosity (Fig. 1). Great care was taken to leave enough bone attached to the rotator cuff. The long head of the biceps was found partially torn in one patient and scarred in three patients. A tenodesis of the long head of the biceps was performed in all patients. The condition of the rotator cuff was assessed

Table 1 Patient demographics

Patients	Age	Sex	Fracture	Approach for reduction and wire fixation	Sequelae	Time to arthroplasty (months)	Osteotomy of the greater tuberosity	Follow-up (months)	Complications
1	56	F	3 part	Closed	Nonunion	9	No	27	
2	62	F	4-part fracture dislocation	Closed	Malreduction	2	No	24	Malposition of greater tuberosity
3	51	F	4 part	Open deltopectoral approach	AVN, nonunion	8	No	25	
4	61	M	3/4 part fracture	Open superior approach	Nonunion	12	No	24	
5	60	F	3-part fracture	Open deltopectoral approach	AVN, nonunion	11	Yes	22	
6	55	M	3/4 part fracture	Open deltopectoral approach	AVN, nonunion	10	No	24	
7	67	F	4-part fracture dislocation	Closed	AVN, nonunion	8	No	21	
8	54	M	3-part fracture	Open deltopectoral approach	Infection, AVN, nonunion	10	No	24	
9	72	M	3-part fracture	Closed	Malreduction	3	No	20	
10	59	F	3-part fracture dislocation	Open deltopectoral approach	Nonunion	9	Yes	20	
11	63	F	3-part fracture	Open superior approach	AVN, nonunion	7	No	18	
12	60	F	3/4 part fracture	Open deltopectoral approach	Malreduction	6	No	18	

AVN, avascular necrosis.

intraoperatively, and one patient had a supraspinatus tear that was repaired at the time of surgery. The condition of the glenoid was satisfactory in all patients and the glenoid cartilage was not eroded.

The prosthesis was inserted and the height was adjusted by reducing the tuberosity fragments together and assessing the ability to cover the head completely with enough space between the prosthesis and the coracoacromial ligament. The prosthesis was inserted in 20° of retroversion in all patients. Fixation of tuberosities was performed according to the technique described by Boileau *et al.* [12].

The arm was immobilized for 6 weeks after which physiotherapy of the shoulder was initiated.

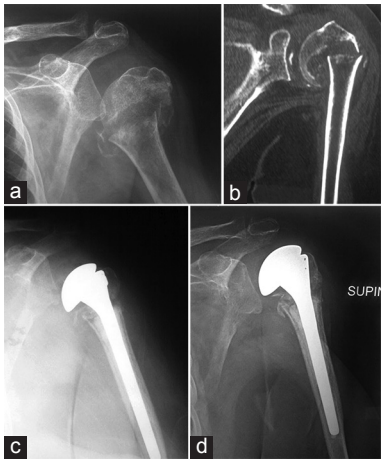
Results

Patients were followed up at monthly intervals for the first 6 months then at 3 months' intervals; at each visit, follow-up radiographs were performed. Patients were assessed clinically and radiographs were analyzed. The Constant score was used to evaluate the results. The mean follow-up was 22.25 months (range 18–27).

At 18-month follow-up, there was a significant relief in pain, with a mean score of 12.92 ($P < 0.01$) (range 5–15). The ADL had a mean score of 15.33, with significant improvement ($P < 0.01$) (range 10–20). The mean ROM score improved to 25.17 ($P < 0.01$) (range 14–32), and the mean strength (lbs) improved to 12.75 ($P < 0.01$) (range 9–16). The active forward elevation significantly improved to a mean of 116.25° ($P < 0.01$) (range 50–160). The overall Constant score improved from a mean of 20.58 to a mean of 66.17 ($P < 0.01$) (range 48–81) (Table 2).

One patient had a malposition of the greater tuberosity (Fig. 2) and had the lowest Constant score at follow-up. No patients were diagnosed with brachial plexus injury, infection, secondary arthritis, loosening, or fractures during the follow-up period.

Figure 1



(a) Preoperative radiograph showing nonunion of the anatomic neck and displaced lesser tuberosity. (b) Preoperative computed tomography showing avascular necrosis of the head. (c) Early postoperative radiograph with slight inferior subluxation of the prosthesis because of hypotonia of the deltoid muscle. (d) Postoperative radiograph after union of the greater tuberosity and restoration of height of the prosthesis.

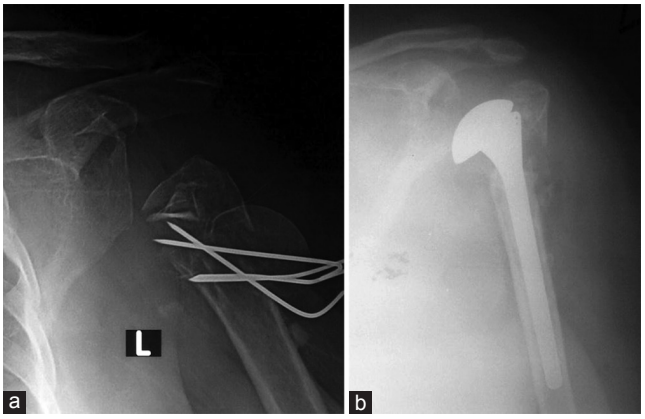
Discussion

The primary treatment for displaced comminuted proximal humeral fractures in the elderly is still controversial. Hemiarthroplasty or reverse shoulder arthroplasty is considered by many to be the primary treatment option for most four-part fractures and many three-part fractures in this age group [13]. However, surgery that preserves the humeral head was reported to have a good functional outcome [14,15].

With preservation of the humeral head, nonunion, malunion, and AVN are reported complications [2]. After the development of these complications, further treatment is often needed. The surgical options at this stage are many and include osteotomies, unconstrained arthroplasty whether hemi or total shoulder, or reverse shoulder arthroplasty [6,16–19].

In our study, we present a series of 12 elderly patients who had complex proximal humeral fractures treated initially by closed or open reduction and K-wire fixation, and who had developed complications such as malreduction, nonunion, AVN, and infection. We performed a hemiarthroplasty to treat these patients,

Figure 2



(a) Preoperative radiograph showing malreduction of the fracture and persistent dislocation. (b) Postoperative radiograph with malposition of the greater tuberosity at a higher level than the prosthesis.

Table 2 Preoperative and postoperative constant scores

Patients	Pain score preoperatively	Pain score postoperatively	ADL preoperatively	ADL postoperatively	ROM preoperatively	ROM postoperatively	Strength preoperatively (lbs)	Strength postoperatively (lbs)	Forward elevation preoperatively	Forward elevation postoperatively	Constant score preoperatively	Constant score postoperatively
1	5	10	6	14	8	26	6	13	55	130	25	63
2	0	15	4	10	4	14	5	9	35	50	13	48
3	5	15	4	18	6	24	5	11	45	90	20	68
4	10	15	8	14	8	26	5	13	60	120	31	68
5	5	15	4	20	6	32	4	14	55	160	19	81
6	5	10	6	14	8	22	7	15	50	100	26	61
7	5	15	4	16	10	30	5	16	65	150	24	77
8	0	5	2	14	4	26	5	14	35	110	11	59
9	0	10	4	14	2	22	4	11	25	95	10	57
10	10	15	6	16	8	28	5	12	35	135	29	71
11	5	15	4	16	6	24	4	12	30	115	19	67
12	5	15	4	18	6	28	5	13	40	140	20	74

ADL, activities of daily living; ROM, range of motion.

and our results showed a statistically significant improvement in pain, ADL, forward elevation, ROM, and power. The active forward elevation improved from 44.2° to a mean of 116.25. The overall Constant score improved from a mean of 20.58 to 66.17.

Many authors presented a series of patients with fracture sequelae and post-traumatic arthritis, treated with hemiarthroplasty or total shoulder arthroplasty, and Mansat *et al.* [17] summarized the similar studies in a comprehensive table. However, those studies included patients with post-traumatic arthritis and all studies were not specific to patients treated with hemiarthroplasty alone.

We followed the classification of fracture sequelae by Boileau *et al.* [8] and their recommendation of performing a hemiarthroplasty in category 1 patients. Primary osteotomy of the greater tuberosity was indicated in two of our patients, and this is different from the osteotomy performed after tuberosity malunion 'second osteotomy', which leads to negative effects on the functional outcome as described by many authors [8,20,21]. In addition, a tenodesis of the long head of the biceps was performed in all patients to reduce the pain [22].

The results of late hemiarthroplasty in our series are inferior to the results obtained with primary hemiarthroplasty for treatment of similar complex fractures in the literature [22,23]. Frisch *et al.* [24] compared their results with acute and late arthroplasty after complex proximal humeral fractures, but most of the late cases were total shoulder replacements.

Norris *et al.* [22] presented a series of 23 patients for late prosthetic shoulder arthroplasty and included both hemi and total shoulder replacements. They classified their patients according to whether the initial surgery was open or closed, and showed that the results of late arthroplasty did not depend on the original fracture treatment, whether open or closed.

To the best of our knowledge, there is no similar study in the literature. We tried to reduce the variables by selecting only category 1 patients who had an initial treatment with K-wire fixation; we performed a hemiarthroplasty and accordingly a predictable and reproducible outcome could be reached.

Hemiarthroplasty should be reserved for category 1 sequelae, provided there is no glenoid arthritis and the condition of the rotator cuff muscles allows full coverage of the humeral head.

Conclusion

With proper classification of late fracture sequelae, hemiarthroplasty, when indicated, can lead to reliable and reproducible clinical results. Successful outcomes are dependent on an intact rotator cuff and on proper tuberosity positioning and healing. The long recovery time and inferior results with late hemiarthroplasty in the elderly population should encourage shoulder surgeons to treat complex humeral fractures primarily with shoulder arthroplasty.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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