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Original article

Evaluation of Short Term Results of Shoulder Hemiarthroplasty in Treatment of Complex Proximal Humerus Fractures and Fracture Dislocations

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Abstract

Background : Proximal humeral fractures account for about 10% of all fractures and is the 3rd most common fracture in the elderly population. Shoulder hemiarthroplasty is performed mainly in patients with Neer four-parts fractures and fracture dislocations, anatomical neck fractures, head-splitting fractures that cannot be anatomically reduced and stabilized and head impression fractures involving greater than 40% of the articular surface. **Aim** : To evaluate the short term results in treatment of complex proximal humerus fractures and fracture dislocations by shoulder hemiarthroplasty .**Patients and methods :** A prospective study conducted on twenty consecutive patients with complex proximal humerus fractures and fracture dislocations who have been treated by shoulder hemiarthroplasty between January 2020 and October 2021 in Benha University hospitals. **Results :** The mean age of the studied patients was 61.1 years old. According to Neer classification most of studied patients found to have 4-part fracture (50%). According to modified constant score**,** five patients (25%) showed excellent results with mean value of 84.4. Eight patients (40%) showed good results with mean value of 65.3. Five patients (25%) showed fair results with mean value of 44.6. Two patients (10%) showed poor results with mean value of 24. The mean duration of postoperative follow up was 14.4 months.**Conclusion :** Shoulder hemiarthroplasty is a reliable method for treatment of acute complex proximal humerus fractures and fracture dislocations which are not amenable for fixation.

Keywords: shoulder hemiarthroplasty ; proximal humerus fractures ; proximal humerus fracture dislocation

Introduction

Proximal humeral fractures account for about 10% of all fractures and is considered the 3rd most common fracture in the elderly population following hip and distal radius fractures[(1)]. Patients above 60 years old represent about 70% of patients with these fractures with obviously increased incidence in women than men due to osteoporosis[(2)].

Treatment options for complex proximal humerus fractures and fracture dislocations include non-operative management, open reduction and internal fixation and shoulder hemiarthroplasty. Non operative management has poor results with many complications like fracture fragments displacement, soft tissue adhesions, osteonecrosis, malunion, nonunion and shoulder joint degeneration[(3)].

Fixation options are variable including percutaneous pinning, bone sutures, plates and intra-medullary fixation. The poorest results occur in the elderly patients with osteoporosis and complex fracture patterns, while the best results are in young patients with valgus impacted fracture pattern. Any attempt to preserve the native articular surface has the risks of avascular necrosis, malunion, non-union and possibility of revision surgeries[(4,5)].

Many shoulder systems have been developed, some of them short-lived. Most recent ones are characterized by modularity with large variation in head diameters and neck lengths to improve cut surface coverage and correct position of the joint line and to allow easier soft tissue balancing[(6,7)].

Shoulder hemiarthroplasty is generally performed in patients with acute proximal humerus four-parts fractures and fracture dislocations, anatomical neck fractures, head-splitting fractures that cannot be anatomically reduced and stabilized and head impression fractures involving greater than 40% of the articular surface . Additionally, it is an alternative to open reduction and internal fixation for osteoporotic three-part fractures that occur in physiologically older and less active patient. In this situation the poor bone quality may not allow adequate stability with internal fixation to allow early motion [(8)].

The primary goal is to reduce pain and create a fulcrum for elevation and abduction, which is lost in most non operatively treated cases as a result of a vascular head necrosis[(9)].

Timing of the intervention is important to get better results. The best outcome is obtained when these fractures are treated in the acute phase (i.e., within the first 2 weeks). Late arthroplasty surgeries for these fractures have inferior results mostly due to fixed soft tissue

contractures and difficulty in anatomic restoration of the tuberosities[(10)].

Many studies and systematic reviews are carried out aiming to compare among different options of treatment of complex proximal humerus fractures including non-operative, internal fixation and shoulder hemiarthroplasty. These studies concluded that range of motion was better in the hemiarthroplasty group without significant difference regarding pain and infection between internal fixation and arthroplasty especially in 4 part fracture patterns. Conservative group was logically superior regarding infection but obviously inferior regarding pain and range of motion[(11)(12)].

Patients and methods

Pre-operative Evaluation:

This is a prospective case study conducted on twenty consecutive patients with complex proximal humerus fractures and fracture dislocations who have been treated by shoulder hemiarthroplasty between January 2020 and October 2021 in Benha University hospitals. An informed consent was obtained from all patients included in the study.

Inclusion criteria: Complex proximal humerus fractures and fracture dislocations even in polytrauma patients within 4 weeks of trauma. No gender limitation and age was limited to skeletally mature patients. Co-operative willing patients who are medically fit for operation and for anesthesia and those with osteoporosis were included.

Exclusion criteria: Patients with re-constructible proximal humerus fractures which can be internally fixed, pathologic proximal humerus fractures, open proximal humerus fractures, active shoulder joint infection, impaired shoulder function prior to trauma (i.e, stiffness, arthritic shoulder, or massive rotator cuff arthropathy) and those with neurologic disorders affecting function of upper extremity were all excluded from the study.

A detailed sheet was taken for all patients including personal history, history of present illness, past history, general examination and local neurovascular assessment of the affected limb.

All patients were examined radiologically by X-Ray and CT Scan to clarify fracture pattern and proper diagnosis.

All patients were operated on by Bigliani/Flatow prosthesis (manufactured by Zimmer Biomet, USA). It is a modular prosthesis with variable head diameters and heights and also with different sizes and

lengths of humeral stems that were implanted with bone cement.

The Ethics Committee of Faculty of Medicine, Benha University, Egypt approved this study code (MD 4-1-2020)

Operative Intervention:

Inter-scalene block under ultrasound guidance administrated. General anesthesia and neuromuscular paralytic agents were then given to all patients. Patients were given intravenous antibiotic (1.5 gm Ampicillin/Sulbactam Sodium) on induction of anesthesia. The patient is placed in beach-chair position and standard delto-pectoral approach is used for exposure.

Control of the lesser tuberosity is achieved by identifying the tuberosity and subscapularis tendon anteriorly in the shoulder just posterior to the conjoined tendon. Stay sutures of no.5 Ethibond are placed through the subscapularis tendon just medial to its osseous insertion on the lesser tuberosity. Control of the greater tuberosity and attached posterior superior rotator cuff is obtained by passing no.5 Ethibond sutures through the rotator cuff tendons just medial to their insertion on the greater tuberosity. One suture is passed at the junction of the supraspinatus and infraspinatus and a second one is passed at the junction of the infraspinatus and teres minor.

The humeral head fragment is identified and may be dislocated or split into two or more fragments. The humeral head is removed with locking forceps and kept on the sterile field for later use as bone graft material.

The humeral shaft is progressively reamed until the reamer that is used corresponds to the diameter of the prosthesis to be implanted. The bicipital groove is located and four 2-mm holes are drilled in the humeral shaft approximately 1 cm distal to the fracture site, two on each side of the bicipital groove. No.5 Ethibond sutures are passed through the holes for use later in tuberosity fixation.

The trial humeral implant is then assembled by selecting a stem with a diameter corresponding to the largest diaphyseal reamer used and a head size corresponding to the size of the removed head fracture fragment. Placement of the prosthesis at the correct height and version is checked by many ways as mentioned before. Then, canal is prepared for final prosthesis fixation.

The medullary canal is irrigated to remove blood and other debris. A cement restrictor is placed in the humeral canal to create a 1-cm distal cement mantle. Cement was pushed down into the upper humerus with finger pressure. The humeral implant attached to the

prosthetic holder is introduced into the humeral shaft to the appropriate height and version. The cement is allowed to fully cure and all excess cement is removed.

Autogenous bone graft is taken from the humeral head fragment and placed between the greater and lesser tuberosities and between the tuberosities and the humeral diaphysis. The tuberosities were mobilized utilizing the stay sutures previously inserted in attached tendons. The sutures in the tuberosities are used for horizontal fixation while the sutures of the shaft are used for longitudinal fixation.

A suction drain was inserted and closure of the subcutaneous tissue and skin was carried out. The arm was immobilized in a shoulder abduction brace.

Intravenous antibiotic (1.5 gm Ampicillin / Sulbactam Sodium) was given twice daily for 5 days followed by oral antibiotic (1 gm Amoxicillin sodium/potassium clavulanate) twice daily for further one week.

Rehabilitation program is demonstrated and encouraged since postoperative day one.

Post-operative Evaluation:

All the patients were followed up for about 12 months and evaluated clinically and radiologically **(Figure 1A,1B,1C).**

Clinical Evaluation: All patients were assessed regarding shoulder modified constant score and patient satisfaction.

Radiograph Evaluation: All patients were evaluated radiologically regarding joint reduction, stem position, cementation, tuberosity position, tuberosity resorption, tuberosity union, heterotrophic ossification and glenoid erosion. The radiographs obtained immediately after operation and sequentially during period of follow up.

Complications were assessed including intra-operative complications, early post-operative complications and complications during the period of follow up.

Statistical Analysis:

Data management and statistical analysis were done using SPSS version 25. (IBM, Armonk, New York, USA)

In the statistical comparison between the different groups, after testing for normality the significance of difference was tested using one of the following tests; student's *t*-test was used to compare between mean of two groups of numerical (parametric) data, for continuous non- parametric data Mann-Whitney *U*- test was used, ANOVA (analysis of variance) was used to compare between more than two groups of numerical (parametric) data, for continuous

non- parametric data Kruskal-wallis test was used, pearson and spearman rank correlation coefficient (r) test was used correlating different parameters. *P* value <0.05 was considered statistically significant (S).

Results

Patient Characteristics

All patients were evaluated for their age, sex, occupation, affected limb side, dominant arm, mechanism of injury, classification, associated injuries, associated diseases, duration till operation and follow up period **(Table 1).**

Radiological Results

All patients were evaluated radiologically regarding joint reduction, stem position, cementation, tuberosity position, tuberosity resorption, tuberosity union, heterotrophic ossification and glenoid erosion. The radiographs obtained immediately after operation and sequentially during period of follow up **(Table, 2).**

Functional Results

- **Modified Constant Score (MCS)**: Five patients (25%) showed excellent results with mean value of 84.4 and 4.4 standard deviation**.** Eight patients (40%) showed good results with mean value of 65.3 and 5.8 standard deviation**.** Five patients (25%) showed fair results with mean value of 44.6 and 4.4 standard deviation**.** Two patients (10%) showed poor results with mean value of 24 and 0.9 standard deviation **(Table, 3).**
- **MCS and Patient Satisfaction :** Results showed highly significant correlation between MCS and patient satisfaction with p-value of <0.001 **(Table, 4).**
- **MCS showed significant correlation with many factors : (Table 5)**
  - Pre-injury level of activity with p-value of 0.02.
  - Postoperative development of glenoid erosion with p-value of 0.002.
  - Joint reduction with p-value of 0.002.
  - Stem position with p-value of 0.04.
  - Tuberosity union with p-value of 0.04.
- **Correlation Between MCS and Different Variables : (Table 6)**
  - Results showed significant negative correlation between MCS and age (r= -0.56) with p-value of 0.01.
  - Results showed significant negative correlation between MCS and duration till operation (r= -0.53) with p-value of 0.02.

Results of Complications

- **Wound Complication:** Two patients (10%) showed superficial wound

infection which responded effectively to antibiotics and did not significantly affect shoulder function**.**

- **Inadequate Cementation:** Three patients (15%) showed inadequate cementation which did not significantly affect MCS with mean value of 59.67 +/- 20.50 and p-value of 0.5.

- **Prosthetic Migration:** Eight patients (40%) showed non concentric joint reduction which significantly affected MCS with mean value of 46.38 +/- 17.95 and p-value of 0.002.

- **Heterotopic Ossification:** Five patients (25%) showed grade 1 heterotrophic ossification which did not significantly affect MCS with mean value of 64.80 +/- 17.54 and p-value of 0.3.

- **Stem Malposition:** Seven patients (35%) showed non neutral stem position which significantly affected MCS with mean value of 45.57 +/- 12.5 and p-value of 0.04.

- **Glenoid Erosion:** Six patients (30%) showed mild glenoid erosion which significantly affected MCS with mean value of 41.00 +/- 15.71 and p-value of 0.002.

- **Tuberosity Complications:**
  - Four patients (20%) showed non anatomical tuberosity position which did not significantly affect MCS with mean value of 54.00 +/- 14.54 and p-value of 0.2.
  - Four patients (20%) showed partial tuberosity resorption which did not significantly affect MCS with mean value of 52.00 +/- 15.25 and p-value of 0.1.
  - Eight patients (40%) showed delayed tuberosity union with MCS mean value of 61.90 +/- 16.80 while two patients showed tuberosity malunion with MCS mean value of 42.50 +/- 19.46. This significantly affected MCS with p-value of 0.04.

- **Shoulder Stiffness:** Two patients (20%) showed very limited range of motion with MCS mean value of 24 +/- 0.9 who scored poor results.

Table, 1: Study group regarding patient characteristics.

		Study group (n=20)	
Age (mean ± SD)		**61.1±7.6 years**	
Sex	Female	10	50.0%
	Male	10	50.0%
Occupation	Housewife	7	35.0
	Retire employee	7	35.0
	Employee	3	15.0
	Worker	3	15.0
Side	LT	8	40.0
	RT	12	60.0
Dominant arm	No	8	40.0
	Yes	12	60.0
Mechanism of injury	Fall on ground	9	45.0
	RTA	8	40.0
	Pedestrian	2	10.0
	Electric shock	1	5.5
Classification "Neer"	4-part fracture	10	50.0
	4-part fracture dislocation (anterior)	8	40.0
	3-part fracture dislocation (anterior)	1	5.0
	3-part fracture dislocation (posterior)	1	5.0
Associated injuries	No	18	90.0
	DER fracture (Rt)	1	5.0
	Supra-inter condylar fracture of humerus (Lt)	1	5.0
Associated diseases*	HTN	9	45.0
	DM	6	30.0
	Asthma	1	5.0
	Stroke (Lt limbs)	1	5.0
	Cardiac	1	5.0
Pre-injury level of activity	No	7	35.0
	Normal	13	65.0
	Sub-normal	7	35.0
Duration till operation/days (mean ± SD)		11.9 ± 7.6	
Follow Up duration/ months (mean ± SD)		14.4 ± 3.6	

*** more than one disease in the same patient**

(Table 2) Radiological findings of the studied group

			No.	%
	Concentric		**12**	**60.0**
Joint Reduction	Not concentric		8	40.0
		Inferior sublaxation < 5mm	5	25.0
		Superior migration < 5mm	2	10.0
		Superior migration > 5mm	1	5.0
Stem Position	Neutral		13	65.0
	Not neutral		7	35.0
		Valgus	4	20.0
		Varus	3	15.0
Cementation	Adequate		17	85.0
	Inadequate		3	15.0
Tuberosity Position	Anatomical		16	80.0
	Not anatomical		4	20.0
		Inferiorized	1	5.0
		Lateralized	2	10.0
		Posteriorly Rotation	1	5.0
Tuberosity resorption	No		16	80.0
	partial resorption		4	20.0
		<50%	2	10.0
		>50%	2	10.0
Tuberosity Union	United		10	50.0
	Delayed union		8	40.0
	Mal-united		2	10.0
Heterotrophic Ossification	No		15	75.0
	Mild (Grade 1)		5	25.0
Glenoid Erosion	No		14	70.0
	Mild		6	30.0

Table, 3: Study group regarding MCS

	No.	%	Mean ± SD
Excellent	5	25.0	84.4 ± 4.4
Good	8	40.0	65.3 ± 5.8
Fair	5	25.0	44.6 ± 4.4
Poor	2	10.0	24 ± 0.9
Total	20	100.0	60.8 ± 19.7

Table, 4: MCS regarding Patient Satisfaction.

		N	Mean	S.D	Test of sig.	p-value
Modified CS	**Dissatisfied**	2	24.00	1.41	12.9	<0.001*
	Neither	4	50.50	10.85		
	Satisfied	11	64.18	13.20		
	Very Satisfied	3	86.33	4.73		

Table, 5; Factors showing significant correlation with MCS regarding.

			N	MCS Mean	S.D	Test of sig.	p-value
Pre-injury level of activity	**Normal**		13	67.08	15.93	2.1	0.02*
	Sub-normal		7	49.00	21.69		
Glenoid Erosion	**Mild**		6	41.00	15.71	3.8	0.002*
	No		14	69.21	14.62		
Joint Reduction	**Concentric**		12	70.33	14.60	3.3	0.002*
	Not Concentric		8	46.38	17.95		
	Not Concentric	**Inferior sublaxation < 5mm**	5	43.20	19.95	---	
		Superior migration < 5mm	2	54.50	21.92		
		Superior migration > 5mm	1	--	--		
Stem Position	**Neutral**		13	64.08	20.63	2.2	0.04*
	Not Neutral		7	45.57	12.5		
	Not Neutral	**Valgus**	4	63.25	14.50	---	
		Varus	3	43.00	15.87		
Tuberosity Union	**United**		10	72.30	12.26	3.7	0.04*
	Delayed union		8	61.90	16.80		
	Mal-united		2	42.50	19.46		

(Table 6) :Correlation between MCS and different variables.

	r	**p-value**
Age	-0.56	0.01*
Duration till operation	-0.53	0.02*

r= pearson correlation

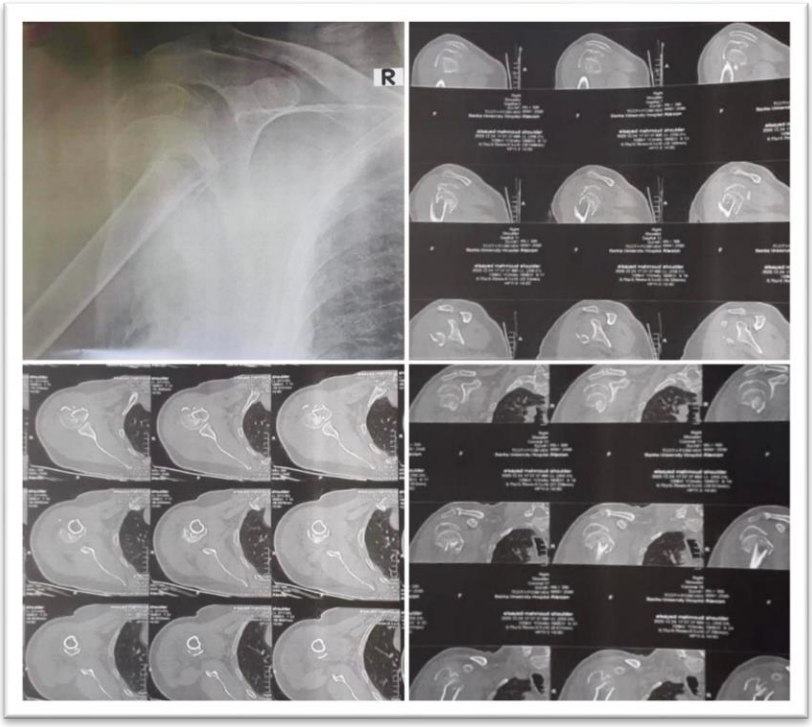

Figure 1A: Preoperative X-Ray and CT images for male patient 55 years old with 4-part proximal humeral fracture. Patient had normal pre-injury level of activity.

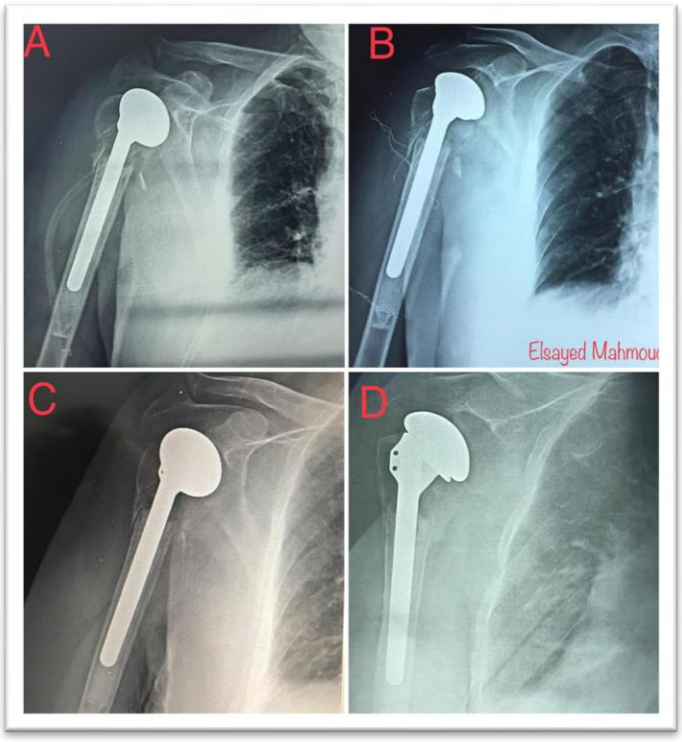

Figure 1B: Postoperative X-Rays. **A:** Immediate postoperative X-Ray, B: 6 weeks after surgery, C:3 months after surgery. D:Final X-Ray 14 months after surgery showed concentric joint reduction, neutral stem position, adequate cementation and united tuberosities in anatomical position.

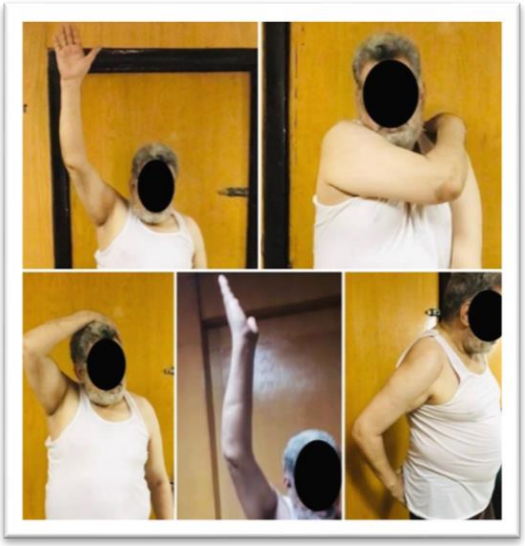

Figure 1C: Clinical follow up after 14 months from surgery. patient was very satisfied scoring 90 points with modified constant score. Patient showed no pain, returned to normal daily life activities with full ROM except only some limitation in internal rotation (dorsum of hand reached to sacroiliac junction. Patient was graded as excellent result.

Discussion

Shoulder hemiarthroplasty is a surgery that can reduce pain, restore shoulder biomechanical function and range of motion [13,14]. In a controlled clinical trial comparing shoulder hemiarthroplasty and conservative treatment of proximal humerus fractures showed improvement in function, quality of life and pain relief with shoulder hemiarthroplasty surgery compared with conservative treatment [15,16].

By using the modified Constant score, our score ranged from 23 points to 90 points with a mean score of 60.8 ± 19.7 points (mean CS 60.3 ± 18.9 points) for twenty patients. There were five patients (25%) with excellent results, eight patients (40%) with good results, five patients (25%) with fair results and two patients (10%) with poor results.

Many studies have reported nearly similar results with a mean Constant score ranging from 50 points to 57.5 points [17,18,19,20,21,22].

Better results were reported by many authors with a mean Constant score ranging from 64 points to 75.8 points [22,23,24], while lower results have been also reported with a mean Constant score ranging between 35 and 49 points [25,26,27,28,29].

We have always tried to recover the fragments of greater and lesser tuberosities into the anatomical position and firmly fixed to the stem during surgery. We also harvested cancellous bone from the humeral head and carried out bone grafting, which will facilitate the healing of the greater and lesser tuberosities. Our study showed significant correlation between modified constant score and tuberosity union with mean score of 72.30 for united tuberosties and p-value of 0.04 between united, delayed united and malunited tuberosities.

Similar results obtained by many authors [30], who found that the results of partial shoulder replacement surgery would achieve the best results if the tuberosities were healed and that significant pain and shoulder function limitation occurred in patients with nonunion of greater and lesser tuberosities [30,31].

Determining stem version and height also are primary aspects to prevent failures. Incorrect version of the stem reduces the healing ability of the tuberosities and increases the risk of implant instability [32,33]. Intra-operative fluoroscopic criteria, guide pins attached to the prosthesis, extra-medullary jig fixed to the elbow and anatomic landmarks have been proposed [34,35,36]. A study reported that

lengthening of the humerus increases the risk of tuberosity detachment, malunion or nonunion, which will lead to a decrease or loss of rotator cuff function while shortening will result in loss of deltoid tension, compromising its function [37,38].

Correlation between tuberosities displacement and further fatty infiltration of rotator cuff muscles after shoulder hemiarthroplasty for proximal humerus fracture was documented [39]. Since the original technique was described, some methods of tuberosities fixation and stem designs were developed to ensure a good functional result [40]. The most popular complication that affects the results is the failure of fixation and non-union which will lead to pain, loss of function and non-compliance with rehabilitation program [41].

Early prosthetic replacement of the proximal humeral head after fracture leads to a better outcome than late replacement [42,43]. Different studies stated that the incidence of complications was higher when surgery was delayed for more than three weeks and found statistically significantly better functioning patients treated within two weeks in comparison with those treated more than two weeks after the initial injury. Other authors have described similar findings [44,45].

These reported results are similar to our study results which showed significant negative correlation between modified constant score and duration till operation (r= -0.53) with p-value of 0.02. However, our study was limited to cases with acute fractures only and all our studied patients were operated on within 4 weeks from onset of trauma. By contrast, some authors found no difference between final shoulder function and the length of time to operation [46,,47,48].

In this study, eight patients (40%) showed non concentric joint reduction which significantly affected modified Constant score with mean value of 46.38 +/- 17.95 and p-value of 0.002. These findings were also reported in many studies with a percentage of non concentric reduction ranging between 20 and 30 of cases [27,37,38,45].

Severe complications such as infection and revision due to prosthetic loosening were unusual and heterotopic bone formation, although not uncommon, appeared to have a minimal effect on function [29]. These result cope with our study which fortunately did not show major complications as infection and loosening and also showed no significant correlation between modified constant score and developed heterotrophic ossification

(grade 1) that occurred in five patients with p-value of 0.3.

In this study, there were only two patients (10%) with superficial infection that responded well to antibiotic treatment. Another study reported 9 cases from 163 cases with early superficial infections, all of which were successfully treated with antibiotics [(24)].

In this study, six patients (30%) showed mild glenoid erosion which significantly affected MCS with mean value of 41.00 +/- 15.71 and p-value of 0.002, but this study lacked long term follow up. A study with a review of 34 studies involving 581 cases of proximal humerus replacement, found that glenoid erosion with painful glenoid arthrosis was the most common reason for conversion to total shoulder arthroplasty. Although these results cannot be generalized, they highlighted a clinical problem which may limit the long-term success of humeral head replacement in a select population of patients for whom there are limited surgical alternatives. Also, another study reported that preoperative absence of erosion of the glenoid was associated with greater improvement in shoulder function and level of comfort after hemiarthroplasty ($p < 0.001$) [(49,50)].

Conclusion

Shoulder hemiarthroplasty surgery is a reliable method for treatment of acute complex proximal humerus fractures and fracture dislocations which are not amenable for fixation. It can reduce pain, restore shoulder biomechanics and range of motion with good patient selection and when the surgical technique is done properly regarding height and version of the stem and tuberosity fixation.

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