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Functional outcomes of reverse total shoulder arthroplasty in acute proximal humeral fractures versus post-traumatic sequelae

Ahmed Adel Abdelaty Abdo [1], Tarek Abdelaziz [1], Mohamed Omar Soliman [2], Mohamed Ibrahim Rakha [1], Asser Abdelhay Sallam [3]

[1] Department of Orthopedic Surgery and Trauma, Suez Canal University, Ismailia. Egypt

[2] Department of Orthopedic Surgery and Trauma, Cairo University. Egypt

[3] Department of Orthopedic Surgery and Trauma, Suez University. Egypt

Proximal humeral fractures account for 4–6 % of all fractures and are the third most prevalent fracture pattern in the elderly. Reverse total shoulder arthroplasty (RTSA) is a frequently utilized surgical procedure for treating this fracture. Aim. To improve the functional outcome and quality of life of patients with acute proximal humeral fractures and post-traumatic sequelae using reverse total shoulder arthroplasty. Subjects and Methods. This comparative study was conducted on a total of 20 patients with 3- or 4-part proximal humeral fractures aged more than 55 years, 10 patients were suffering from acute fractures (group I) and 10 patients with post-traumatic sequelae (group II). All patients were evaluated preoperatively and followed up postoperatively at 6 weeks, 3 months, 6 months and one year for functional outcomes. Radiological, clinical and functional outcomes were assessed by a goniometric range of motion (ROM), Constant-Murley score, and the Arabic version of the Quick DASH score. The rate of postoperative complications and the need for revision surgery were also reported. Results. In group I, the DASH and VAS score declined from 88.30 (± 8.23) and 5.90 (± 1.28) in the 6th weeks after surgery down to 34.30 (± 11.55) and 0.70 (± 0.48), respectively after 1 year. The Constant score increased from 14.70 (± 5.67) to 67.30 (± 14.98). All scores showed almost similar improvements in all three parameters in group II. Moreover, similar improvements in the deltoid muscle power, function and ranges of motion were reported in patients of both groups. Conclusion. Reverse shoulder arthroplasty provides favorable post-operative outcomes among elderly patients with 3-part and 4-part fractures of the proximal humerus. Indication for RTSA will not be affected by whether patients are presenting with acute or post-traumatic sequelae fractures. Level of evidence: Therapeutic study level III.

Травми проксимального відділу плечової кістки становлять 4–6 % усіх переломів і посідають третє місце за поширеністю серед ушкоджень у людей похилого віку. Реверсивне тотальне ендопротезування плечової кістки (RTSA) є часто використовуваною хірургічною процедурою для їхнього лікування. Мета. Покращити функціональний результат та якість життя пацієнтів із переломами проксимального відділу плечової кістки та посттравматичними наслідками за допомогою RTSA. Методи. Це порівняльне дослідження проведене за участю 20 пацієнтів з 3- або 4-уламковими переломами проксимального відділу плечової кістки віком понад 55 років. Хворих розподілили на 2 групи: I — перелом, 10 осіб, II — посттравматичні наслідки (10 випадків). Усі пацієнти були обстежені до втручання та спостерігалися після операції через 6 тижнів, 3 і 6 місяців та один рік. Радіологічні, клінічні та функціональні результати оцінювалися за допомогою гоніометричного діапазона рухів (ROM), шкали Constant-Murley та арабської версії шкали Quick DASH. Також повідомлялося про частоту післяопераційних ускладнень та необхідність повторної операції. Результати. У групі I бал за шкалами DASH та VAS знизився з 88,30 (±8,23) та 5,90 (±1,28) через 6 тижнів після операції до 34,30 (±11,55) та 0,70 (±0,48) відповідно через рік. Бал за шкалою Constant збільшився з 14,70 (± 5,67) до 67,30 (± 14,98). Усі показники майже однаково покращилися за всіма трьома параметрами в групі II. Окрім того, у пацієнтів обох груп виявлено зростання функції та діапазону рухів дельтоподібного м'яза. Висновок. Реверсивне ендопротезування плечового суглоба забезпечує сприятливі післяопераційні результати в пацієнтів похилого віку з 3- та 4-уламковими переломами проксимального відділу плечової кістки. Показання до RTSA не залежатимуть від того, чи мають пацієнти гострі чи посттравматичні наслідки переломів. Ключові слова. Переломи проксимального відділу плечової кістки; посттравматичний; реверсивне ендопротезування плечового суглоба.

Keywords. Proximal humeral fractures; post-traumatic; acute; reverse shoulder arthroplasty

Introduction

Proximal humerus fractures (PHFs) are the third most prevalent form of fracture in individuals over 65 years of age, accounting for 4–6 % of all fractures in that population. Furthermore, PHFs are the third most prevalent form of osteoporotic fractures, with a lifetime risk of 13 % for women aged 50 and more [1].

The majority of proximal humerus fractures (stable, minimally displaced fractures) are treated nonoperatively, most typically with sling immobilization followed by early and gradual physical therapy and rehabilitation [2].

On the other hand, one of the most commonly used surgical techniques is reverse total shoulder arthroplasty, which has become the preferred treatment for older patients with non-reconstructable PHFs because the patient can achieve excellent motion even with unhealed tuberosities or an incompetent rotator cuff. It can also be used for non-surgical therapy of fracture sequelae and revision of failed HA operations [3].

In addition, reverse total shoulder arthroplasty (RTSA) has become more popular globally in treating different traumatic and degenerative glenohumeral disorders and irreversible rotator cuff arthropathies [4].

RTSA can be utilized for acute and post-traumatic PHFs. Nevertheless, the functional effects of RTSA in these fractures remain debatable.

Therefore, in our study, we compared the functional outcomes of reverse total shoulder arthroplasty in patients with recent traumatic proximal humerus fractures and posttraumatic sequelae.

Patients and methods

This comparative prospective study was conducted at the orthopedic emergency department, or the orthopedic outpatient clinic, Suez Canal and Cairo University hospitals following the approval of our Institutional Research Board on 17th May 2022 (Approval #ORT/4918). It was conducted on a total of 20 patients aging more than 55 years of age and presenting with proximal humeral fractures: 10 patients having three and four-part proximal humeral fractures (group I) and 10 patients with post-traumatic sequelae in the form of non-union or malunion of the anatomical neck of humerus with minimal calcar hinge, arthritis, or failed hemiarthroplasty (group II). Patients of both groups were managed by Reverse Shoulder System.

Patients with signs of infection around the shoulder, axillary nerve injury, acromial and scapular fractures, paralytic or neurologic disorders that affect prosthesis stability or pathological fractures were excluded from the study.

All study patients were subjected to preoperative evaluation through full history taking and clinical examination. The Modified British Medical Research Council (MRC) Scale was used for assessment of the deltoid muscle power [5]. Painless active range of motion and painless resting position of the limb were tested.

Plain shoulder radiographs (anteroposterior and lateral views) were ordered for all patients. In true AP views, the superior-inferior glenoid bone loss was assessed using the Favard classification which classifies the glenoid bone erosion into five types: from E0 to E4 [6]. The inferior glenoid tilt [7] was assessed using the Habermeyer classification. In the axillary lateral view, the posterior glenoid wear was assessed using Walch classification, which classifies the posterior wear as follows: A1, mild concentric glenoid wear; A2, marked concentric glenoid wear; B1, eccentric posterior glenoid erosion; B2, with a biconcave glenoid; C, greater than 25° retroversion [6]. Our spectrum and focus for group II patients were post-traumatic sequelae of the proximal humerus. Therefore, only glenoid arthritis patients who didn't need any augments or biografting were included, such as patients with Walch types A1 and B1. Patients with types A2, B2 and C were excluded from the study.

Computerized tomography and 3D-CT were ordered to evaluate the glenoid retroversion angle by the Friedman method. An axial computed tomography slice was taken at the level of the tip of the coracoid and a line is drawn from the medial scapula border through the middle of the glenoid. The retroversion was calculated by the angle between the glenoid joint line and the perpendicular of Friedman's line. Glenoid vault depth was measured as follows: Axial slice was used to assess the vault depth (a minimum of 10 mm is required for central peg accommodation) [8–11]. MRI was ordered routinely for all patients to assess the condition of the rotator cuff tendons. Splinting was applied, and analgesics were continued till the time of surgery.

Surgical technique

Under general anesthesia with interscalene block, the patient was placed on a beach chair position at the edge of the table to allow free shoulder movement. A third-generation cephalosporin was given preoperatively. For the acute fracture group, a deltopectoral approach was adopted. An 8–10 cm incision was performed starting from the coracoid process to the deltoid insertion and then through the clavipectoral facia. Subscapularis bursae were removed, the bicipital groove was identified then biceps tenotomy was done with tenodesis. Greater tuberosity was identified and stay sutures were placed. The rotator interval was identified and opened to the glenoid. Lesser tuberosity was identified and a stay suture in the subscapularis tendon was placed. The biceps tendon is excised down to the glenoid. Four suture loops are passed through the posterosuperior cuff, flush with the tendon insertions onto the greater tuberosity; the needles are removed from two of the loops, which are passed from medial to lateral through the infraspinatus and teres minor, respectively; and the other two loops are passed from lateral to medial through the same tendons. Traction sutures are used to pull the tuberosities apart. The anterior capsule is excised to expose the anterior glenoid rim. Two retractors are placed at the anterior and posterior borders of the glenoid, respectively.

Tuberosities were pulled apart and the labrum was excised to expose the glenoid. Dissecting the capsule from the anterior glenoid down to and around the inferior pole so the upper axillary scapular border could be easily palpated and seen. After removal of the capsule and labrum, a guide wire was drilled 13 mm anterior to the posterior rim and 19 mm above the inferior glenoid rim with 10 degrees inferior tilt. The baseplate of the delta prosthesis was then placed over the guide wire to verify the right position of the central wire. Then we reamed the glenoid to remove only enough bone to make it flat.

The central hole was drilled then we inserted the central peg into the central hole. By using a 2 mm drill bit, a drill was done for the inferior screw after baseplate rotation adjustment to the axillary scapular border. After inferior screw placement, we drilled and then inserted the superior screw into the base of the coracoid process using a similar technique. A trial glenosphere was then inserted over the baseplate and any bone that abuts against the humeral polyethylene was removed.

The conical-shaped cemented trabecular metal reverse humeral stem was implanted in all patients of group I. We gradually increased the size of broaches for the proximal humerus until rotational stability was achieved provided that any cortical contact was avoided. Then a drill hole was made in the humerus for fixation of the tuberosities. Finally, the polyethylene insert was applied, and the wound was irrigated and closed in layers.

For the post-traumatic sequelae group, a similar surgical technique was utilized, but specific technical difficulties were encountered as follows: when a revision of hemiarthroplasty was planned, an extensile deltopectoral approach was adopted. Scar tissue is excised. Close attention was paid to the attachments of the latissimus dorsi, teres major, and pectoralis major tendons. Deltoid muscle was preserved. These should be spared and marked to ensure optimal function following surgery. When dissecting the glenoid capsule, the axillary nerve and its branches were identified and preserved. Complete glenoid visualization required peri-glenoid capsular resection. To expose the base of the coracoid and the anterior glenoid neck, which measured about 3 cm, the subscapularis was peeled off the glenoid neck. The head was hammered and then removed. The humeral stem was loose and was easily removed with an impactor from below without the need for osteotomy. The cement was extracted with a cement removal set. Yet, some blowout of the lateral cortex occurred in one patient. The plug and the distal cement to the tip of hemiarthroplasty left inside the medullary canal. A classical approach for the glenoid reaming and baseplate fixation and glenoshphere was adopted. The conical-shaped cemented trabecular metal reverse humeral stem was also inserted in all the patients of both groups. Stability was evaluated following the implantation of the humeral component and joint reduction. Adequate tension was checked by assessing the tension of the soft tissues, such as the conjoint tendon, which is a key stabilizer of the shoulder girdle.

In patients where there was an old anatomical neck fracture malunion or nonunion that was internally fixed, the PHILOS plate was removed and the anatomical neck and tuberosities were osteotomized. Tuberosities were then reattached to the implant and humeral shaft as closely as possible to its anatomic side. The same conical-shaped cemented trabecular metal reverse humeral stem was implanted in those patients.

In patients with arthritis, through a deltopectoral approach, adducting and externally rotating the arm while pushing the elbow forward and upward helped the humeral head to dislocate. To determine the level of humeral resection and the anatomical neck, anterior and inferior osteophytes were excised from the proximal humerus. Typically, the humeral head was removed at a retroversion angle of approximately 30 degrees. The humeral canal was reamed using different reamer sizes and then prepared by humeral stem broaches. A version rod was attached to the broach handle to monitor the version during humerus preparation. A conical-shaped cemented trabecular metal reverse humeral stem was inserted. The steps of glenoid exposure and preparation were similar to patients of group one.

Post-operative Follow-up

Follow-up visits were planned at 2 weeks, 6 weeks, 3 months, 6 months and one year post-operatively. The sutures were removed two weeks after surgery. An arm sling was applied for the first 6 weeks, during which no active ROM or weightlifting was allowed. Immediate postoperative active motion of the cervical spine, elbow, wrist, and hand were encouraged. Passive extension, elevation, external rotation and internal rotation were postponed till the 6^{th} week. Between the 6^{th} to 12^{th} week, the passive range of motion was continued, and patients started a protected gradual active ROM. After the 12^{th} week, strengthening of the muscles around the shoulder was allowed.

Post-operative Outcome Measures

Radiological outcomes (stability, radiolucency, scapular notching, heterotopic ossifications and other possible complications) were assessed by plain radiography at 2 weeks, 6 weeks, 3 months, 6 months and one-year intervals 9 (example of pre-operative versus post-operative radiological findings after 1 year is presented in Figs. 1 and 2 of patients from group I and Figs. 3, 4, and 5 of patients from group II). Clinical and functional outcomes were assessed by a goniometric range of motion (ROM), Constant-Murley score 10, and the Arabic version of the Quick DASH score 11. The rate of postoperative complications and the need for revision surgery were also reported.

Statistical analysis

Collected data were coded, entered, and analyzed using Microsoft Excel program software. Data analysis was done by Statistical Package for Social Science (SPSS) version 26.

We conducted the Shapiro-Wilk test and found that our numeric data were normally distributed, accordingly they were represented as mean (± SD). Categorical data were expressed as proportions. Demographic characteristics were compared using the Fisher exact test and the Chi-square test, while the T-test was used for mean differences of the clinical scores. The level of significance using the p-value was statistically significant if it was < 0.05.

Results

The patients' demographics are presented in Table 1. Both groups in our study had a comparable age distribution, with Group I having a mean age of 69.40 ± 10.57 years (range: 56–86) and Group II having a mean age of 70.80 ± 7.89 years (range: 56–81). Additionally, we included both males and females. Regarding comorbidities, 4 patients in Group I had no chronic illnesses, while most of the remaining patients suffered from hypertension (3/10). In Group II, half of the patients were diabetic, and 3 patients had both diabetes and hypertension. Concerning the type of fractures in Group I, 40 % of the patients had 3-part fractures, while 60 % had 4-part fractures, with no head-splitting fractures. Figure 1 represents patient with acute proximal humeral fracture who restored satisfactory function after RTSA. Figure 2 represents another example of acute proximal humeral fracture that is 73-year-old female patient who presented with a 4-part fracture and history of old humeral shaft fixation.

As for post-traumatic sequelae in group II, 40 % of the cases had arthritis, 50 % had malunion, and only 10 % had hemiarthroplasty. The patient with hemiarthroplasty underwent revision surgery by RTSA due to aseptic loosening. The patient had the first surgery 5 years ago and presented with progressive pain and limitation of movement (Fig. 3). Another example is a female patient with secondary advanced shoulder arthritis after reduced shoulder dislocation 5 years ago and underwent RTSA (Fig. 4). Furthermore, a 55-year-old patient presented with a fracture malunion. Radiographs revealed a malunited fracture of the anatomical neck of his right humerus. The malunited anatomical neck was osteomatized and a classic RTSA was performed (Fig. 5).

Table 1

Distribution of the demographic and clinical characteristics in both groups

	Group I (n=10)	Group II (n=10)
Age, years:		
Mean+SD	69.40 ±10.57	70.80 ±7.89
Range	(56-86)	(56-81)
Gender:		
Male	4 (40%)	5 (50%)
Female	6 (60%)	5 (50%)
Chronic illnesses:		
Diabetes	2 (20%)	5 (50%)
Hypertension	3 (30%)	1 (10%)
Diabetes and Hypertension	1 (10%)	3 (30%)
No chronic illness	4 (40%)	1 (10%)
Fracture Type:		
3-part fractures	4 (40%)	—
4-part fractures	6 (60%)	
Head-splitting fractures	0 (0%)	
Post-traumatic squelae:		
Malunion	—	5 (50%)
Arthritis		4 (40%)
Hemiarthroplasty		1 (10%)

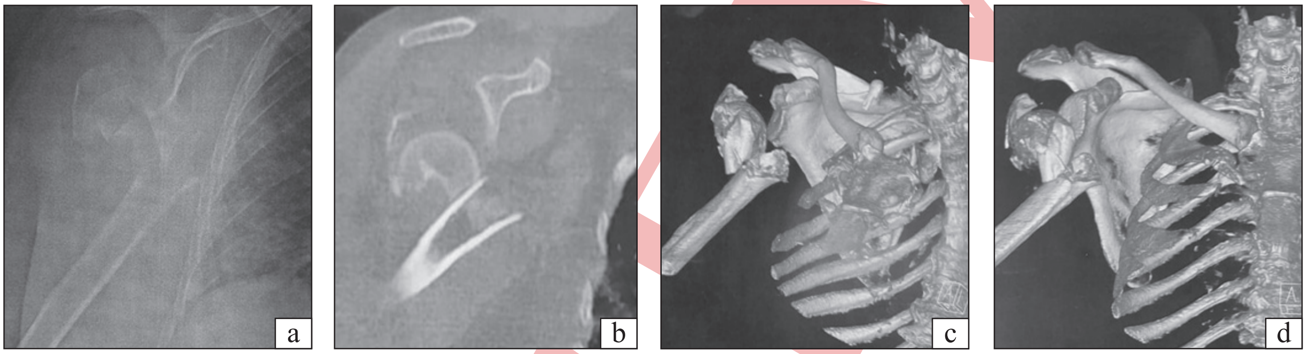
Notes: * Quantitative data are expressed in mean+SD, and range. Qualitative data are presented as numbers (percentage). Group I includes patients with acute proximal humeral fractures. Group II includes patients with post-traumatic sequelae.

There was a marked improvement among the patients in both study groups when we compared their DASH scores at 6, 12, 24, and 48 weeks. However, upon examining the presence of any differences in the DASH score between both groups at each follow-up period, we found no significant difference (table 2).

The VAS score also declined markedly across the follow-up period, however, this improvement didn't vary significantly between both groups, since similar improvements were noted among the patients in both study groups (table 2).

The results of the Constant-Murley score showed that the patients' total score improved markedly over time. However, this improvement did not vary significantly across both groups (table 2).

The mean range of motions of all patients increased significantly by one year in both groups.



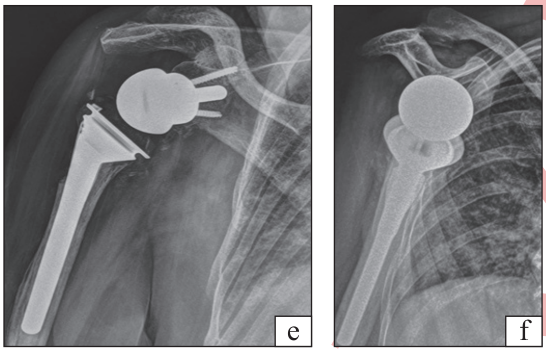


Fig. 1. A 63-year-old female patient presented after fall on the ground on the day of trauma with acute proximal humeral fracture: a) preoperative plain radiograph with 4-part proximal humerus fracture; b, c, and d) preoperative CT images; e and f) postoperative anteroposterior and lateral radiographs of reverse total shoulder arthroplasty

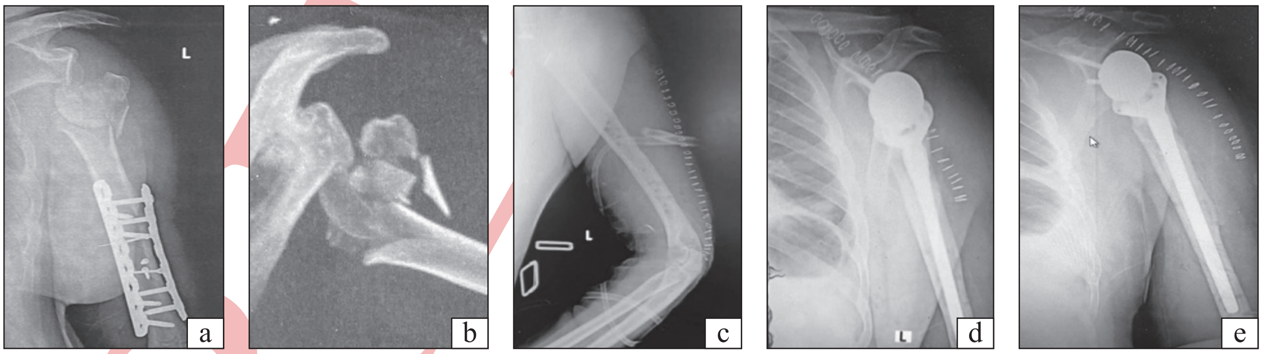


Fig. 2. A 73-year-old female patient presented with 4-part fracture of the proximal humerus. Patient had history of old humeral shaft fixation: a) preoperative plain radiograph of the proximal humeral fracture; b preoperative CT image; c) plate and screws were removed. d and e. postoperative lateral and anteroposterior radiographs of reverse total shoulder arthroplasty; f) post operative range of forward elevation, internal rotation, shoulder abduction, and external rotation at final follow-up

However, the improvement was slightly and statistically insignificantly higher among patients in group II regarding Abduction and Flexion, while patients in group I had better external rotation and internal rotation ranges (table 3).

Table 2

Distribution of the functional outcome scores at 6, 12 24, and 48 weeks after surgery in both groups

	Group I (n = 10)	Group II (n = 10)	P value
	Mean (±SD) Range		
DASH			
6 weeks	88.30 (± 8.23) (73–98)	91.00 (± 3.52) (84–95)	0.359
12 weeks	61.40 (± 11.80) (40–76)	61.30 (± 8.38) (46–70)	0.983
24 weeks	37.20 (± 13.16) (19–56)	39.00 (± 8.27) (23–46)	0.719
48 weeks	34.30 (± 11.55) (19–52)	35.80 (± 7.14) (21–42)	0.732
VAS			
6 weeks	5.90 (± 1.28) (4–8)	5.80 (± 0.78) (5–7)	0.837
12 weeks	3.50 (± 1.17) (2–5)	3.70 (± 0.82) (3–5)	0.665
24 weeks	1.20 (± 0.78) (0–2)	1.20 (± 0.42) (1–2)	1.000
48 weeks	0.70 (± 0.48) (0–1)	0.60 (± 0.51) (0–1)	0.660
CS			
6 weeks	14.70 (± 5.67) (6–25)	16.00 (± 3.39) (12–21)	0.544
12 weeks	37.90 (± 9.93) (25–55)	35.30 (±3 .94) (30–41)	0.457
24 weeks	65.60 (± 16.57) (40–90)	61.10 (± 6.36) (51–72)	0.439
48 weeks	67.30 (± 14.98) (45–90)	62.70 (± 5.92) (54–72)	0.389

Notes: DASH: Disabilities of the Arm Shoulder and Hand; VAS: Visual analogue score; CS: Constant-Murley score. Quantitative data are expressed in mean+SD and range. * p-value. < 0.05: statistically significant.

Table 3

Distribution of the mean range of motion at 6, 12 24, and 48 weeks after surgery in both groups

	Group I (n = 10)	Group II (n = 10)	P value
	Mean (±SD) Range		
Abduction			
6 weeks	37.80 (± 14.69) (23–72)	36.20 (± 11.25) (26–65)	0.788
12 weeks	(89.10 (± 34.95) (40–147)	98.50 (± 22.34) (60–131)	0.484
24 weeks	142.70 (± 30.96) (89–175)	146.50 (± 15.33) (110–164)	0.734
48 weeks	145.50 (± 28.42) (97–175)	149.30 (± 13.88) (115–166)	0.710
Flexion			
6 weeks	51.10 (± 29.49) (26–110)	41.60 (± 10.98) (29–56)	0.360
12 weeks	92.50 (± 31.92) (58–155)	92.40 (± 13.62) (73–119)	0.993
24 weeks	149.20 (± 27.08) (105–180)	149.10 (± 16.14) (114–167)	0.992
48 weeks	152.90 (± 25.54) (113–180)	156.80 (± 9.31) (145–170)	0.659
External rotation			
6 weeks	12.90 (± 4.55) (6–20)	11.60 (± 3.53) (8–18)	0.486
12 weeks	26.80 (± 11.38) (12–45)	22.60 (± 4.69) (17–32)	0.302
24 weeks	43.90 (± 15.87) (23–73)	40.30 (± 10.36) (27–55)	0.557
48 weeks	44.90 (± 15.82) (24–73)	41.70 (± 10.07) (28–55)	0.597
Internal rotation			
6 weeks	27.40 (± 5.89) (21–40)	24.60 (± 4.64) (18–32)	0.254
12 weeks	39.70 (± 6.91) (31–55)	38.10 (± 3.90) (32–43)	0.534
24 weeks	52.60 (± 11.84) (41–77)	51.60 (± 6.81) (42–65)	0.820
48 weeks	55.10 (± 10.58) (44–77)	53.70 (± 6.91) (45–69)	0.731

Notes: Quantitative data are expressed in mean+SD and range. * p < 0.05: statistically significant.

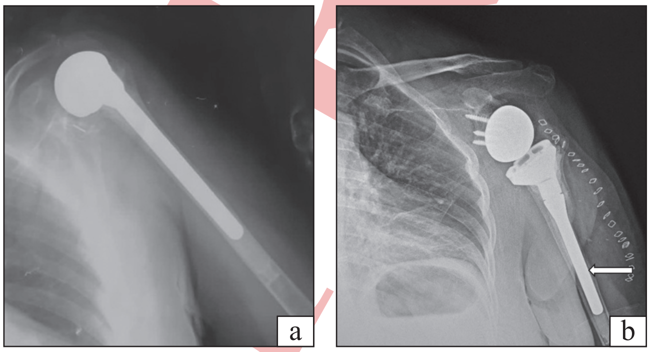


Fig. 3. A 58-year-old male patient presented with aseptic loosening of shoulder hemiarthroplasty: a) preoperative plain radiograph of the hemiarthroplasty; b) postoperative radiographs of reverse total shoulder arthroplasty (arrow indicates lateral cortex blowout during cement extraction)

A significant increase in power and function was noted when comparing the 6-week follow-up results with the one-year follow-up results. Nevertheless, there was no statistically significant difference between both groups in terms of this improvement (table 4).

The improvement in the power and function was higher in group II compared to group I in the 12-, 24-, and 1-year follow-up. On the other hand, the 6-week follow-up results showed patients in group I had more power and function (table 4).

Few intraoperative and postoperative complications occurred. Intraoperatively, in the hemiarthroplasty revision patient, a lateral cortex blow-out occurred while removing the stem. Another patient developed a superficial infection 3 weeks after surgery. Surgical debridement was done. The other two patients in the posttraumatic sequelae group got axillary nerve palsy as proved by postoperative electrophysiological studies. During regular outpatient follow-up visits, one of them regained axillary nerve functions 2 months after surgery without any further interventions. The other patient needed axillary neurotization from the radial nerve branch to the medial head of the triceps. He regained satisfactory functional outcomes 6 months later.

Discussion

We successfully improved the postoperative outcomes of all our recruited patients regarding the range of movement, pain, and functional scores following RTSA. Nevertheless, we found no statistically significant difference in the outcomes of patients in terms of the onset of injury (acute fracture versus post-traumatic sequelae).

Treatment for acute proximal humeral fractures has been extensively described in the literature, and RSA has been proposed as a surgical option for acute

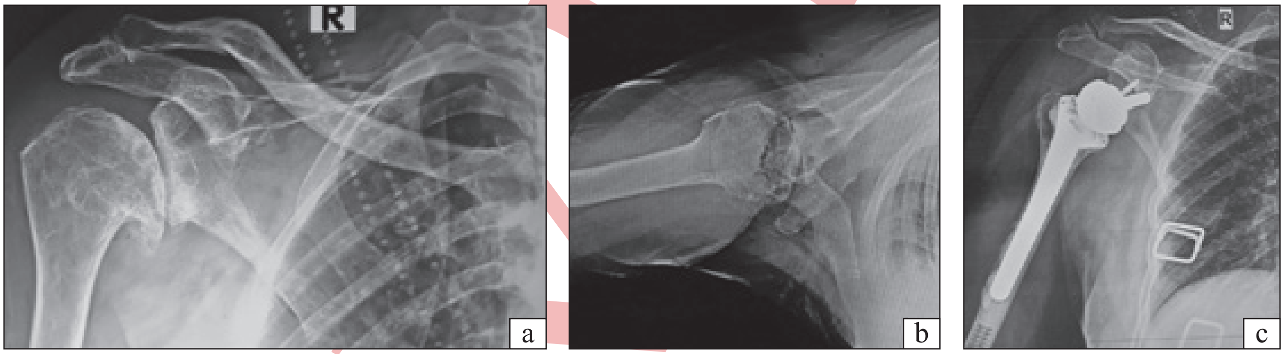


Fig. 4. A 66-year-old female patient with secondary advanced osteoarthritis after old reduced anterior shoulder dislocation: a and b) preoperative plain anteroposterior and axillary radiographs with advanced osteoarthritis of the shoulder; c) postoperative radiograph of reverse total shoulder arthroplasty; d) post operative range of shoulder abduction, external rotation, forward elevation and internal rotation, at final follow-up

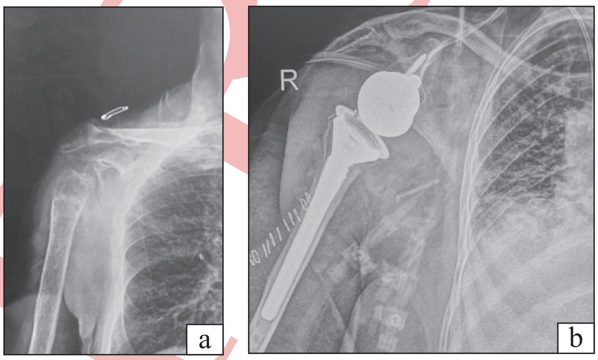


Fig. 5. A 55-year-old male patient with a fracture malunion of the anatomical neck of his right humerus: a) preoperative plain radiograph of the fracture; b) postoperative radiograph of reverse total shoulder arthroplasty

Table 4

Distribution of the deltoid muscle power
and function domains of the Constant score
at 6, 12 24, and 48 weeks after surgery in both groups

	Group I (n = 10)	Group II (n = 10)	P value
	Mean (±SD) Range		
Power			
6 weeks	0.60 (± 0.69) (0–2)	0.20 (± 0.42) (0–1)	0.142
12 weeks	5.70 (± 3.05) (2–11)	6.10 (± 2.60) (2–10)	0.756
24 weeks	16.20 (± 6.54) (4–22)	16.50 (± 5.23) (7–23)	0.911
48 weeks	17.00 (± 5.61) (7–22)	17.40 (± 4.62) (9–23)	0.864
Function			
6 weeks	1.30 (± 1.15) (0–4)	1.00 (± 0.47) (0–2)	0.463
12 weeks	7.20 (± 2.14) (0–4)	7.20 (± 1.31) (5–9)	1.000
24 weeks	13.40 (± 3.13) (8–18)	13.70 (± 2.54) (10–17)	0.817
48 weeks	14.50 (± 2.71) (10–18)	14.80 (± 2.25) (11–18)	0.791

Notes: Quantitative data are expressed in mean+SD and range. * $p < 0.05$: statistically significant.

complex fractures in elderly patients 1, 2, 12, 13. However, the treatment of the post-traumatic sequelae is a challenge for the surgeon and the literature on this topic is limited.

Sebastia-Forcada conducted a matched case-control study designed to investigate the outcomes of secondary RSA after failed internal fixation for proximal humeral fractures. They found that at the 2-year follow-up, the mean clinical scores in the sequelae group were significantly lower than in the acute group although the differences were not clinically relevant. This was similar to our findings but at the 6-week follow-up, because in the following periods in our study, the post-traumatic group showed better scores and clinical outcomes.

In the sequelae group in Sebastia-Forcada's study, the Constant and DASH scores significantly improved from preoperative to postoperative. At the 2-year follow-up, all the patients except one achieved improvement in the range of motion. While one patient had anterior forward and abduction less than 90 degrees. At the last follow-up, 28 patients (93.3 %) were satisfied with the results of their RSA, and 2 were dissatisfied. They also reported that there were no significant differences in postoperative pain, motion, or ability for activities of daily living in the subgroup of patients younger than 70 years in comparison to those older than [14].

Paszicsnyek et al carried out a matched cohort analysis study which included a group of patients suffering from acute and post-traumatic sequelae. In that study, they performed a subgroup analysis of the fracture group to examine the difference in range of motion and outcome scores. Like our results, they found no significant difference, despite detecting a general tendency towards superior outcome scores for the acute fracture [15].

Although previous studies reported worse outcomes and higher complication rates have been reported after arthroplasties for fracture sequelae compared with arthroplasties for acute fractures like the study by Nikola et al who included 40 patients in their study, who were treated with reverse shoulder arthroplasty for sequelae of proximal humeral fracture and acute fracture [16].

As our results, Nikola et al results showed that a group of patients treated with RSA without previous surgery in comparison with patients treated with RSA after previous surgery had better functional results. Where the external rotation was 24°, active elevation was 102°, and internal rotation was up to L4 in all patients. In patients without previous surgery treated with RSA, elevation was 116°, external rotation 24°, internal rotation up to L3. In patients with previous surgery treated with RSA, elevation was 84°, external rotation 19°, internal rotation up to L4. These findings are not statistically significant [16].

In their patients with acute fracture treated with RSA elevation was 124°, external rotation 28°, internal rotation up to L4. In patients with chronic or sequelae of the fractures treated with RSA elevation was 114°, external rotation 28°, internal rotation up to L3. They also reported that the differences between these two groups are not significant. Our patients too had an external rotation of 26.80° and internal rotation of 39.70° after 12 weeks in the acute fracture group, while in group II, we found decreased ranges, where the mean external rotation was 22.6° and the mean internal rotation was 38.1°.

The constant score in all their patients was 54. The constant score in patients without previous surgery treated with RSA was 68 and with previous surgery was 42. This was similar to our findings, where the mean constant score in group II was 62.70 after 1 year, but in group I our patients had a better score than that reported by Nikola et al [16].

Despite the differences in the functional and clinical outcomes between both groups, whether in our study or previous studies, are statistically insignificant, the better outcome in the acute fracture group could be attributed to the bone quality and muscle balance of the patients in the post-traumatic sequelae. Previously surgically treated patients had scar tissue, shortening of the soft tissue and malunion bone abnormalities. Furthermore, it is elaborated that functional results are better if tuberosities of the humerus are preserved [12–16].

This study was a prospective comparative study which represented a strength along with using objective and subjective measures for assessment of patients' outcomes. Additionally, no patients were lost to follow-up. The equal distribution of males and females across both our study groups represented a major strength by reducing the possible bias that could be attributed to the influence of gender on postoperative outcomes.

Nevertheless, our study used a small sample size which represents a limitation. Therefore, future research including larger sample sizes and extended follow-up periods is necessary to better define the indications for surgery and RTSA in PHFs.

Conclusion

Reverse shoulder arthroplasty provides favorable post-operative outcomes among elderly patients suffering from acute 3-part, and 4-part fractures of the proximal humerus. Furthermore, the indication for RTSA will not be affected by whether patients are suffering from acute or post-traumatic sequelae fractures.

All ranges of motion were similarly improved in both groups. The mean DASH score dropped from 88.3 and 91 preoperatively to 34.3 and 35.8 at final follow-up, in groups I and II, respectively. The VAS score decreased from 5.9 and 5.8 in groups I and II, respectively, to less than one, indicating improvement in pain after surgery. The Constant-Murley score increased from 14.7 and 16 to 67.3 and 62.7 in groups I and II, respectively, indicating similar restoration of satisfactory function. A few complications occurred in 4 patients of group II including superficial infection, axillary nerve palsy and lateral cortex blow-out.

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FUNCTIONAL OUTCOMES OF REVERSE TOTAL SHOULDER ARTHROPLASTY IN ACUTE PROXIMAL HUMERAL FRACTURES VERSUS POST-TRAUMATIC SEQUELAE

Ahmed Adel Abdelaty Abdo [1], Tarek Abdelaziz [1], Mohamed Omar Soliman [2], Mohamed Ibrahim Rakha [1], Asser Abdelhay Sallam [3]

[1] Department of Orthopedic Surgery and Trauma, Suez Canal University, Ismailia. Egypt
[2] Department of Orthopedic Surgery and Trauma, Cairo University. Egypt
[3] Department of Orthopedic Surgery and Trauma, Suez University. Egypt

* Ahmed Adel Abdelaty Abdo, MSC: ahmedozadeloz2013@gmail.com; https://orcid.org/0000-0003-0407-0340
* Tarek Abdelaziz, MD: tareksh64@yahoo.com; https://orcid.org/0009-0001-3230-0791
* Mohamed Omar Soliman, MD: omarsoli@hotmail.com; https://orcid.org/0009-0006-0797-0255
* Mohamed Ibrahim Rakha, MD: mohrakha2005@gmail.com; https://orcid.org/0000-0002-9225-7393
* Asser Abdelhay Sallam, MD, PhD: assersallam@hotmail.com; https://orcid.org/0000-0002-0936-8296