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ORIGINAL PAPER

Periprosthetic humeral fractures associated with reverse total shoulder arthroplasty: incidence and management

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Abstract
Purpose The purpose of this study was to record the incidence and management of periprosthetic humeral fractures (PHF) using reverse total shoulder arthroplasty (RTSA) in our institution.
Methods We performed a retrospective study of 203 RTSA implanted in 200 patients between 2003 and 2014. The mean follow-up was 78.82 months (range, 12–141). Mean age of the study cohort was 75.87 years (range, 44–88). There were only 25 male patients (12.5 %). We assessed the presence of periprosthetic humeral fractures studying the medical files and X-rays of all patients.
Results We identified seven periprosthetic humeral fractures in 203 RTSA (3.4 %): three intra-operative (1.47 %) and four post-operative (1.97 %). The average age at the time of the fracture was 75.14 years (59–83). All patients were women (100 %). Three patients with post-operative fractures type B were treated by osteosynthesis, and one patient with post-operative fracture type A was treated conservatively. All intra-operative fractures needed cerclage wire and in one case long cemented stem. All our periprosthetic fractures healed.
Conclusions Surgical treatment with osteosynthesis in type B post-operative fractures with a stable stem is recommended. Conservative treatment is sufficient in non-displaced type A post-operative fracture. Special attention should be paid to bone quality patients using non-cemented stems in primary surgery but especially in revision shoulder surgery.

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Introduction

Reverse total shoulder arthroplasty (RTSA) was described by Paul Grammont in 1987 and has been used for more than 25 years in Europe [1]. In April 2004, the Food and Drug Administration allowed re-introduction of a RTSA into the United States. Actually, this semiconstrained shoulder prosthesis has been recommended to treat a wide variety of shoulder problems such as rotator cuff arthropathy, glenohumeral arthritis with rotator cuff deficiency, massive rotator cuff tears with pseudoparalysis, complex proximal humeral fractures and the sequelae of proximal humeral fractures [2]. RSTA provides pain relief, restores overhead elevation, and provides satisfying subjective clinical outcomes in most of the patients [3].

Despite the great popularity of the RTSA, a high complication rate has been reported, that is four times that of anatomical total shoulder arthroplasty [4], ranging from 19 to 68 % [5–7]. Periprosthetic humeral fractures (PHF) have been considered an unusual event, but recently they are less rare as a consequence of the increasing number of shoulder arthroplasty performed [8]. They are generally due to a simple fall on the arm. The main risk factor is humeral osteopenia; in fact most of the patients are elderly women. The treatment options include conservative and surgical management, depending on fracture and patient personality.

The incidence of PHF around shoulder arthroplasties is similar to hip and knee prostheses between 0.5 and 3 % [9–11]. PHF account for approximately 20 % of all complications related to total shoulder arthroplasty [12].

They are classified according to humeral location. There are multiple PHF classifications, but the Wright and Cofield classification [13] is the most frequently used. This classification was originally created for post-operative fractures and it is limited to those occurring near the tip of the humeral stem. Type A fractures include the tip and extend proximally. Type B fractures extend distally from the tip. Type C fractures occur distal to the end of the humeral component. Later, Campbell proposed a classification system that included tuberosity and metaphyseal fractures and it is more adequate for intra-operative fractures, particularly with the use of press-fit implants [14]. Campbell divided these fractures into four types related to the fracture site. Type 1 included the greater or lesser tuberosity, type 2 metaphyseal portion or surgical neck, type 3 proximal humeral diaphysis, and type 4 the mid- and distal diaphysis.

There are not many articles in the literature that specifically study periprosthetic humeral fractures in RTSA and always fall into general complications of total shoulder arthroplasties [15–17].

The purpose of this study was to evaluate the real incidence and management of periprosthetic humeral fractures using reverse total shoulder arthroplasty (RTSA) in our hospital over 11 years.

Material and methods

We retrospectively reviewed the medical files and X-rays of two institutional series: a first series of 22 cases involving Delta III cemented (DePuy Orthopedics, Inc., Warsaw, IN, USA) in 22 patients from 2003 to 2007 and a second series of 181 cases in 178 patients involving Delta Xtend (DePuy Orthopedics, Inc., Warsaw, IN, USA) and Lima SMR (Lima-LTO, Italy) from 2008 to 2014. Of this second series 64 cases were cemented Delta Xtend (31.52 %), 42 cases were uncemented Delta Xtend (20.68 %), 66 cases were uncemented Lima SMR (32.51 %) and nine cases were cemented Lima SMR (4.43 %) (Table 1).

The mean follow-up was 78.82 months (range, 12–141) and the mean age of both study cohorts was 75.87 years (range 44–88). There were 175 females (87.5 %) and only 25 male patients (12.5 %).

All surgeries were performed by three senior authors (FMM, CGF and YLM).

The indications for surgery in our series included (Table 1) massive rotator cuff tear without arthritis in 49 cases (24.13 %), rotator cuff arthropathy in 71 cases (34.97 %), revision surgery (fracture sequelae, pseudoarthrosis and failed shoulder arthroplasty) in 40 cases (19.70 %) and acute complex proximal humerus fracture in 43 cases (21.18 %).

All surgeries were performed with patients in the beach chair position. We use the superolateral approach in massive rotator cuff tears that are not repairable and in cuff tear

Table 1 Types of RTSA divided by indications

Types of RTSA	Delta III	Cemented Delta Xtend	Uncemented Delta Xtend	Uncemented Lima SMR	Cemented Lima SMR	Total
Massive rotator Cuff tear	8 cases (3.94 %)	5 cases (2.46 %)	17 cases (8.37 %)	19 cases (9.35 %)	0 cases	49 cases (24.13 %)
				2 IntraO PHF (2010–2012)		
Arthropathy	10 cases (4.92 %)	22 cases (10.83 %)	17 cases (8.37 %)	22 cases (10.83 %)	0 cases	71 cases (34.97 %)
Revision	4 cases (1.97 %)	13 cases (6.40 %)	6 cases (2.95 %)	14 cases (6.89 %)	3 cases (1.47 %)	40 cases (19.70 %)
Surgery	**1 PostO PHF (2005)**			**1 PostO PHF (2012)**		
				1 IntraO PHF (2012)		
Fractures	0 cases	24 cases (11.82 %)	2 cases (0.98 %)	11 cases (5.41 %)	6 cases (2.95 %)	43 cases (21.18 %)
				1 PostO PHF (2010)	**1 PostO PHF (2014)**	
Total	22 cases (10.83 %)	64 cases (31.52 %)	42 cases (20.68 %)	66 cases (32.51 %)	9 cases (4.43 %)	203 cases

RTSA reverse total shoulder arthroplasty, *PHF* periprosthetic humeral fractures
The periprosthetic humeral fracture-PHF are in bold text

arthropathy. The deltopectoral approach is used in stiff shoulders, in acute complex proximal humeral fractures and for revision surgery. Pre- and post-operative radiographs were analyzed by two surgeons (CGF and YLM) independently. Conventional radiographs of the affected shoulders in true anteroposterior (AP) and scapular lateral views and anteroposterior (AP) and lateral views of the full humerus with fracture were performed before surgery and at recent follow-up. Fracture union was defined as the presence of bridging bone on two X-ray views with no evidence of hardware failure and the absence of pain at the fracture site.

Basic patient's subjective evaluations of their shoulder function and satisfaction before the fracture and after surgery were compared (worse, equal, or better).

Results

We identified seven periprosthetic humeral fractures (Table 2) in 203 RTSA (3, 4 %): three intra-operative (1, 47 %) and four post-operative (1, 97 %). The average age at the time of the fracture was 75, 14 years (59 to 83). All patients who suffered PHF in our institution were women and all fractures were due to a low energy fall. The average time from surgery to fracture was 12 months (8 to 27). All our periprosthetic fractures healed.

The overall complication rate was 28.57 % (two cases) due to neurological problems.

All patients with PHF except two, with radial nerve palsy, reported a satisfying result at the latest follow-up.

Post-operative PHF

The rate of post-operative periprosthetic humeral fractures after total primary RTSA and after revision with reverse shoulder arthroplasty was 0.98 % (two cases) and 0.98 % (two cases), respectively.

Three patients with post-operative fractures type B Wright-Cofield were treated by osteosynthesis with plates and cerclage wires and one patient with post-operative fracture type A was treated conservatively. The humeral stem was stable and preserved in all these cases. Osteosynthesis consisted of a long posterior LCP plate in one case, two lateral plates in another case and one anterior LCP plate in the last one. This patient had a preoperative radial nerve palsy partially recovered at nine months with physiotherapy.

These PHF post-operative fractures healed at a mean time of 18 weeks (range 16–20).

Intra-operative PHF

The rate of intra-operative fractures in primary RTSA and after revision with reverse shoulder arthroplasty was 0.98 (two cases) and 0.49 % (one case), respectively.

Table 2 Periprosthetic humeral fractures: patient data and management

Case	Year	Age (years)	Side	Type fracture	W-Cofield classification	Campbell classification	Time after implantation	Prior surgery RTSA	Type RTSA	Cem / stem	Treatment	Time to union	Complications
1	2005	72	L	PostO	B	4	7 months	Revision hemi	Delta III	Yes / long	Plate+allograft+ cerclage	5 months	None
2	2010	7	R	IntraO	–	1	–	Massive SE tear	Lima SMR	No / short	Cerclage wire	2 months	None
3	2010	81	R	PostO	B	4	27 months	Fracture	Lima SMR	No / long	Plate+cerclage wire	5 months	Radial nerve palsy (PreoO)
4	2012	59	R	PostO	A	3	8 months	Revision hemi	Lima SMR	No / long	Conservative	4 months	None
5	2012	82	R	IntraO	–	1	–	Massive SE tear	Lima SMR	No / short	Cerclage wire	2 months	None
6	2013	79	R	IntraO	–	4	–	Revision hemi	Lima SMR	No / long	Long stem+ cerclage wire	6 months	Radial nerve palsy (PostO)
7	2014	83	R	PostO	B	4	9 months	Complex fracture	Lima SMR	Yes / long	Two lateral plates	4 months	None

The two proximal metaphyseal (type 1 Campbell) needed cerclage wiring but they didn't require changing the cementless stem.

The only intra-operative shaft fracture (type 4 Campbell) occurred in a revision of a painful hemi-arthroplasty during reaming of the humeral medullary canal and required placement of a long cementless stem and several cerclage wires. The patient had a post-operative radial nerve palsy not recovered, which persisted until the latest follow-up (30 months), and will need a tendon transfer surgery when medical and personal problems allow it.

The two proximal metaphyseal fractures healed at a mean time of ten weeks but the type 4 Campbell post-operative fracture healed in six months.

Discussion

The exponential growth in the use of reverse total shoulder arthroplasty (RTSA) worldwide [8] and broadening of its initial clinical indications has caused the number of complications to increase at the same time [5, 6]. Periprosthetic humeral fractures (PHF) around reversed shoulder stems have been reported as a rare complication [9] but they should be considered very seriously because they worsen the clinical evolution of the patient [18].

Our rate of PHF following RTSA is 3.44 % (seven cases). This rate is comparable with the rates of others published studies [19]. Zumstein et al. [17] reported a systematic review of the literature about complications in RTSA and reviewed 782 RTSA in 761 patients with a minimum average follow-up of 24 months. The global rate for RTSA complication was 24 % with an incidence of PHF of 3.45 % (27 cases) (2 % intra-operative and 1.4 % post-operative). He defined a complication in RTSA as any intra-operative or post-operative event that was likely to have a negative influence on the patient's final outcome, including fractures, infections, dislocations, etc. In another study, King et al. [4] compared 51 uncemented RTSA with 32 cemented RTSA at a minimum two-year follow-up and reported an incidence rate of PHF of 7.2 % (six patients). In this series, PHF were more common in the uncemented group (five patients, 6.02 %) than in the cemented group (one patient, 1.2 %), but the difference was not significant. In our series also it was more common to have PHF with uncemented stems (53.20 %) versus cemented stems (46.79 %). The theoretical advantages of uncemented humeral fixation are decreased operative time, biological ingrowth potential and easier revision of the humeral component if necessary [20]. Campbell et al. [4] identified several technical errors leading to periprosthetic fracture, including over-reaming of the endosteal diaphysis and insertion of an oversized broach or prosthesis, especially in uncemmented stems. For these reasons, Campbell said that press-fit stems should be used only in patients with adequate bone stock to avoid excessive hoop stresses.

PHF in RTSA, in our series, are more common in primary surgery (1.97 %) than during revision surgery (1.47 %). This data can be understood because there were more cases of primary surgery (108 cases) than revision surgery (95 cases).

Our time to fracture union ranged from two to six months and this is comparable to the cases reported in the current literature [19].

Our post-operative PHF rate following RTSA of 1.97 % is quite high, especially when compared with the rate of 0.9 % in the series published by Singh et al. [21], which analyzed more than 2,500 anatomic primary total shoulder arthroplasties and 1,400 humeral head replacements performed over a 33-year period. But our post-operative PHF rate is lower when compared with specific series using RTSA. A rate of 8 % of post-operative PHF (one case) was described in the study by Raiss et al. [22], which reviewed 13 patients with RTSA for osteoarthritis and rotator cuff deficiency after previous surgery for recurrent anterior shoulder instability. Atoun et al. [23] found four late traumatic periprosthetic metaphyseal humeral fractures (12.9 %) in 31 patients using RTSA with a short metaphyseal humeral stem. Three were treated conservatively and one had revision to a stem reverse prosthesis. They thought that with a short metaphyseal stem prosthesis the stress riser remains in the metaphysis and applicable for conservative treatment.

Three of our four post-operative PHF required (Wright-Cofield type B) osteosynthesis with DCP plates and cerclage wires preserving the stable stem. Angelini et al. [24] said that cerclage wire may function as a temporary tool for reduction during surgery or can be used as an implant, and they damage blood supply to bone less than expected. Cameron et al. [25] reported that when treating unstable diaphyseal PHF in the face of well-fixed components, a heavy plate with proximal cerclage wires and distal screws is the treatment of choice.

Our rate of intra-operative PHF during RTSA (1.47 %) is considerable. Two of our intra-operative PHF occurred during insertion or impaction of a humeral trial component or the true humeral prosthesis (type 1 Campbell). These two fractures were stabilized with cerclage wires. The diaphyseal intra-operative PHF (type 4 Campbell) occurred during reaming or broaching of the humerus during revision surgery. This fracture was stabilized by placing a long humeral stem with cerclage wires.

Athwal et al. [11] reported that the treatment of PHF during shoulder arthroplasty begins with prevention and that special care should be taken in patients with documented risk factors (osteopenia, RA, revision surgery, etc.) to avoid increasing stress on the humerus. In our series of PHF all patients were women.

We have not found significant differences in published series regarding the types of PHF and treatment applied between

anatomic total shoulder arthroplasty and RTSA. All PHF are treated based on humeral location, fracture stability, and stem fixation regardless of the type of prosthesis used [16, 20, 22, 23].

This study has several limitations, including its retrospective design and the use of different types of RTSA (cemented and uncemented). It is difficult to ascertain clear guidelines on the satisfactory treatment of PHF because the limited number of patients in the present study but it is similar to the number of other published series [16, 18].

Conclusions

Periprosthetic humeral fractures represent a challenge for orthopaedic surgeons in shoulder surgery. Treatment decisions have to be taken individually, depending on the stability of the prosthesis, fracture location and bone quality.

Surgical treatment with osteosynthesis in type B post-operative fractures with a stable stem is recommended. Conservative treatment is sufficient in non-displaced type A post-operative fracture. Special attention should be paid to bone quality patients using non-cemented stems in primary surgery but especially in revision shoulder surgery.

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Conflict of interest The authors declare they have no competing interests.

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