



# Is the Posterior Approach With Posterior locking compression plate and Anterior Allograft Useful and Safe in the Treatment of Periprosthetic Humeral Fractures Following Reverse Total Shoulder Arthroplasty?

Geriatric Orthopaedic Surgery  
& Rehabilitation  
Volume 13: 1–8  
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DOI: 10.1177/21514593221080961  
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## Abstract

**Introduction:** As the reverse total shoulder arthroplasty (RTSA) surgery has dramatically increased in the last few decades, many complications have followed through. The periprosthetic fracture, at the moment, is still a subject of debate in the orthopedic world. In this monocentric study, along with a literature review of periprosthetic humeral fractures, we would present our institutional experience with the treatment of periprosthetic humeral fractures with a posterior humeral approach, posterior cortex plate fixation, anterior strut allograft, screws, and cerclage wires. **Materials and Methods:** Our study consisted in a prospective monocentric study based on 18 patients, with a mean age of 75.3 years (range 64–88), all following a reverse shoulder total arthroplasty (RTSA). Postoperative follow-ups were taken at 1, 6, and 12 months with objective measurement of shoulder motion and strength, while clinical outcome measures were assessed using the American Shoulder and Elbow Surgeons (ASES score) and visual analog scale (VAS) for pain. Together with that, we performed a literature review focused on the management of periprosthetic humeral fractures after shoulder arthroplasty. **Results:** All fractures consolidated without complication at a mean 4.2 months (range 3–6). At final follow-up, the average active shoulder flexion was 88° (range 62–129°), active abduction 73° (range 52–91°) and active external rotation 22° (range 3–56°). The average ASES score was 73 (range 59–97), while average VAS score was 1.1 (range 0–3). **Discussion:** Surgical treatment of periprosthetic humeral fractures following a shoulder arthroplasty remains a hard challenge for every surgeon, and their treatment must consider fracture's location, displacement, and local bone quality. **Conclusions:** The posterior approach with a posterior plate placement and anterior strut allograft, which is applicable only in case of a B or C type fracture according to Worland classification, could be a good treatment option for periprosthetic humeral fractures.

## Keywords

periprosthetic fractures, humeral fractures, Worland classification, posterior approach, reverse total shoulder arthroplasty

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## Introduction

Since the reverse total shoulder arthroplasty (RTSA) approval by the Food and Drug Administration in 2003,<sup>1</sup> there has been a huge increasing rate of its implant all around the world, which was reported to be as high as 393% from 2001 to 2010.<sup>2</sup> Increasing rates of shoulder arthroplasty yield of course an increasing prevalence of complications, including instability, infection, implant loosening and periprosthetic fracture.<sup>3</sup> The prevalence of these fractures has been reported to range between 1,6% and 2,4% and accounts for 20% of all complications.<sup>4</sup> Periprosthetic fractures can occur intraoperatively or postoperatively: the first ones are usually rare and are more often stemmed from technical errors, whereas the postoperative ones may be related to trauma or loosening of the prosthesis.<sup>5</sup> Significant risk factors for periprosthetic fractures include female gender, significant comorbidities, osteoporosis/osteopenia, rheumatoid arthritis (RA),<sup>6</sup> on-growth stem coating, high size of the implant.<sup>7</sup>

Classification systems have been developed along the time to help guiding treatment. In 1995 Wright and Colfield described a 3 part classification based on the location of the fracture with regard to the tip of the stem.<sup>8</sup> Type A fractures are located at the tip of the prosthesis and extend proximally, type B fractures lie at the tip and do not extend proximally but may extend distally, and type C fractures are located distal to the tip of the prosthesis. They declared that transverse or short type A and B fractures, together with displaced type C fractures, are best managed surgically, whereas long oblique or spiral fractures with stable stem and type C fractures in acceptable alignment could be managed nonoperatively. Later, Campbell et al<sup>9</sup> defined 4 categories related to the fracture site: (A) tuberosities region; (B) metaphyseal portion or surgical neck; (C) proximal humeral diaphysis; and (D) mid- and distal humeral diaphysis. This type of classification results more adequate for intraoperative fractures. Groh et al<sup>10</sup> distinguished Type I fractures as occurring proximal to the tip of the prosthesis; Type II extending from the proximal part of the humeral shaft to beyond the distal tip of the stem; and Type III as fractures lying distal to the tip of the prosthesis. In 2018, Kirchhoff et al<sup>11</sup> developed a more complex classification including 3 sub-classifications: location of the fractures (acromial, glenoidal, and humeral), type of fractures (tuberosities, spiral, oblique, distal), and implant stability (stable, loose). They also proposed a simple algorithm with these 3 classification subtypes to suggest the treatment (ORIF vs conservative or revision). Finally, the AO foundation described a unified classification system for periprosthetic fractures (UCPF),<sup>12</sup> based on the following coding process: the bone is identified by the AO/OTA code; the joint involved is added as a modifier in square brackets after the bone code; the fracture type is based on the location of the fracture in relation to the implant. So, type A fractures involve apophysis adjacent

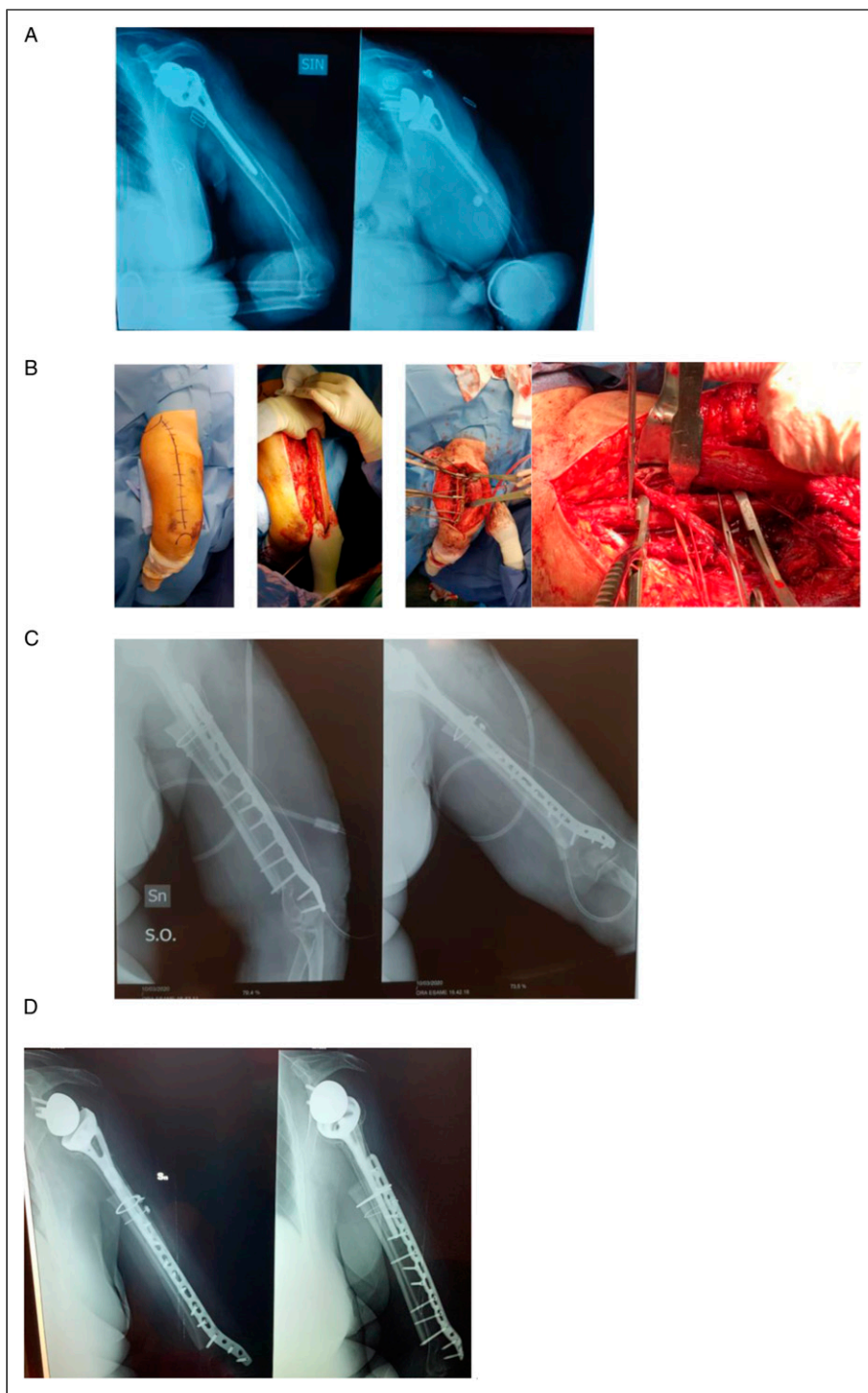
implant with no effect on implant stability; type B fractures regard the bed of the implant or its surrounding; type C fractures the clear of the implant; type D fractures divide the bone between 2 implants; type E fractures include each of the 2 bones supporting the implant; type F fractures are facing and articulating with a hemiarthroplasty.

Osteosynthesis in these fractures could be reached through many approaches: anterior shoulder approach (deltopectoral approach), posterior or lateral approach. The latter 2 enable visualization and protection of radial nerve, and usually posterior approach is generally preferred for more distal fractures, while the first 2 for proximal/mid third fractures. Identification of the radial nerve is always needed when cerclages have to be performed. Independently from the approach, however, in most of the literature papers, the plate is always placed upon the lateral humeral cortex, with the strut allograft on the medial side. On the contrary, in this monocentric study, along with a literature review of periprosthetic humeral fractures, we would present our institutional experience with the treatment of periprosthetic humeral fractures with a posterior humeral approach, posterior cortex plate fixation (LCP extra-articular distal humerus plate 3,5 mm Depuy -Synthes, Johnson & Johnson, New Brunswick, USA), anterior strut allograft, screws and cerclage wires.

## Materials and methods

### Our experience

In our retrospective monocentric study, we identified 20 patients treated with posterior cortex plate fixation for periprosthetic humeral fracture, over a period of 2 years. The study group initially consisted of 20 patients, but 2 of them were lost at follow-up (1 death). Therefore, the final study group consisted of 18 patients, with a mean age of 75.3 years (range 64–88). All these fractures were postoperative fractures following a reverse shoulder total arthroplasty (RTSA). 16 patients sustained a low-energy trauma, caused by a fall, and 2 a high-energy trauma (a road accident and a collision). The mean time from first surgery was 13.4 months (range 6–23). According to Worland classification, 11 fractures were located distal to the tip of the prosthesis (type C) (Figure 1A), while 7 were transverse or short oblique fractures with a stable stem (B2). Stem instability was excluded with x rays and CT scan of the bone segments (10 stems were cemented and 8 were press-fit). Two patients developed a radial nerve palsy after the traumatic event (a patient with high-energy trauma and the other with low-energy trauma), but after exploration of radial nerve during surgery and its decompression, there was a complete healing at 3 months. Postoperatively, there were 2 cases of radial nerve stupor, healed at 3 months with neurotrophic therapy and electrostimulation. Postoperative follow-ups were taken at 1, 6,



**Figure 1 .** (A) Periprosthetic type C fracture second. Worland classification. (B) posterior access with triceps sparing. (C) Protection of the radial nerve with a vessel loop during the reduction maneuvers. (D) Post-op x rays. (E) 6-month follow-up.

and 12 months with objective measurement of shoulder motion and strength, while clinical outcome measures were assessed using the American Shoulder and Elbow Surgeons (ASES score) and visual analog scale (VAS) for pain.

**Surgical technique**

All the patients underwent the surgery in a prone position, with the injured arm laid on a support. In every case it was performed a posterior approach to the humerus with triceps

sparing (Figure 1B). It is essential in this technique to identify and protect both ulnar and radial nerve to avoid neurological sequela. The ulnar nerve is clearly visible in the distal part of the arm, where it must be protected with a vessel loop and followed proximally until the medial intermuscular septum, taking care not to injure it by uncontrolled traction. Then it could be mobilized the triceps muscle, at first retracting it laterally, and later mobilizing it from the lateral intermuscular septum. This permits the whole triceps muscle to be moved towards either the lateral or medial side, to provide access to the humerus (“triceps flip”). At the end, the radial nerve can be detected as its penetration through the intermuscular septum and followed upwards in the radial groove (Figure 1C).

At this point, after the reduction of the fracture, it must be chosen the correct treatment depending on the fracture pattern: for an oblique simple fracture it has to be used a lag screw and a neutralization plate; for a transverse fracture a compression plate; for a multifragmentary fracture a bridge plate. In every case we use an LCP extra-articular distal humerus plate 3,5 mm, which is placed in the posterior cortex of the humerus, with a strut allograft on the anterior cortex. It is now fundamental to put the strut allograft in compression to the bone with a reduction clamp and synthesize the construct with at least 3 tricortical screws distal to the fracture. At the end, the construct is reinforced proximally with 2 or 3 monocortical screws and a couple of cerclage wires (Figure 1D).

Postoperatively, patients are kept in a shoulder immobilizer (sling) for the first 2 weeks, with activity restricted to elbow and wrist exercise to limit loss of motion in these joints. At the third week, after the stitch’s removal, the immobilizer is discontinued, and the patient is allowed to shoulder pendulum. At 4 weeks, formal physical therapy is initiated allowing shoulder range of motion (ROM) to tolerance and isometric rotator cuff and periscapular strengthening. At 3 months, progressive strengthening may be initiated based on healing with gradual return to activities.

## Results

There was no case of secondary infection in any prosthesis nor in any plate implant, and the only complications were 2 patients with wound dehiscence, resolved with a superficial irrigation and debridement. All fractures consolidated without complication at a mean 4.2 months (range 3–6), but the strut allograft osteointegration was present just in 6 out of 18 cases. At final follow-up, the average active shoulder flexion was 88° (range 62–129°), active abduction 73° (range 52–91°) and active external rotation 22° (range 3–56°). The average ASES score was 73 (range 59–97), while average VAS score was 1.1 (range 0–3).

### Literature review

We performed a literature search focused on the management of periprosthetic humeral fractures after shoulder

arthroplasty (Table 1). Inclusion criteria were studies with more than 3 patients, and a minimum follow-up of 1 year. Exclusion criteria were review articles, follow-up of less than 1 year and papers published before the last 10 years. Such details were analyzed as patient demographics, type of treatment, union rates, and functional outcomes.

A single author reviewed studies by a systematic research of Medline, Pubmed, and Cochrane Library, using various combinations of terms: “periprosthetic AND shoulder,” “periprosthetic AND fractures,” “periprosthetic AND humeral fracture,” “RTSA AND fracture,” “humeral fractures AND RTSA.” The author screened the titles and abstracts of the papers identified and acquired the full text of any article potentially eligible.

In total, 8 papers were found eligible to be included in our review of the literature. These included 99 patients treated for periprosthetic humerus fracture after shoulder arthroplasty.

Sewell et al<sup>13</sup> reported a number of 22 periprosthetic fractures, 12 treated with long stemmed humeral component that bypassed the fracture, 8 treated with resection of the proximal humerus and endoprosthesis replacement and 2 treated with clamshell prosthesis. After a mean follow-up of 42 months 12 patients were very satisfied, 3 satisfied, and 3 were dissatisfied.

Martinez et al<sup>14</sup> reported on 6 fractures all treated with ORIF and strut allograft by an anterolateral approach. Average time to union was 5.4 months with all fractures uniting without complications.

Greiner et al<sup>15</sup> reported on 6 cases. Case 1 was treated with LCP + cerclage wires, case 2 was treated with long-stemmed inverse prosthesis, case 3 was treated with long-stemmed reverse shoulder arthroplasty, case 4 was treated with long-stemmed inverse prosthesis, case 5 was treated with long-stemmed prosthesis + CTA head, and case 6 was treated with a Philos long plate + strut allograft + 1 cerclage wire. Case 1 healed 38 months after fracture, case 2 10 months after fracture and had a Constant Score of 48%. Case 3 healed 18 months after fracture and had a Constant Score of 70%. Case 4 healed 13 months after fracture and had a Constant Score of 77%. While case 5 healed and was noted to be doing well, case 6, 18 months after fracture, had no evidence of bone healing nor grafts remodeling but fracture reduction had been maintained.

Carlos García-Fernández et al<sup>16</sup> reported on 7 cases, with a mean age of 75.14 years. One case was treated with plate, strut allograft and cerclage wires; 2 cases with cerclage wires only; 1 with plate and cerclage wires; 1 with a long stem revision and cerclage wires; 1 with 2 lateral plates and the last 1 was treated conservatively. All patients reached bony union at a mean of 18 weeks (range 16–20), but 2 patients suffered from radial nerve palsy (1 occurred pre-operatively and the other intraoperatively).<sup>17</sup>

Jaeger et al<sup>18</sup> reported on 17 fractures, of which 13 treated with ORIF (plate and screws) and 4 with a revision arthroplasty due to loose prosthesis. All the fractures healed

**Table I.** Study Characteristics.

Study	N° of Fractures	Treatment	Mean Follow-Up (Range)	Mean Patient Age (years)	Surgical Approach	Results
Martinez et al <sup>16</sup> (2011)	6	6 ORIF with plate and strut allograft	14 (12–16)	73 (69–79)	Anterolateral approach	All unions without complication, in an average time of 5.4 months
Greiner et al <sup>15</sup> (2011)	6	Case 1: 80-year F; LCP + cerclage wires Case 2: 51-year F; long-stemmed inverse prosthesis Case 3: 70-year F; long-stemmed reverse shoulder arthroplasty Case 4: 62-year F; long-stemmed inverse prosthesis Case 5: 82-year F; long-stemmed prosthesis + CTA head Case 6: 78-year M; philos longplate + strut allograft + 1 cerclage wire	—	—	1 posterior approach 5 anterolateral approaches	Case 1: 38 months after fracture was healed Case 2: 10 months after constant score 48%  Case 3: 18 months after constant score 70%  Case 4: 13 months after constant score 77% Case 5: so far doing well, no pain, important limitation Case 6: 18 months after no evidence bone healing nor graft remodeling fracture reduction maintained
Sewell et al. <sup>13</sup> (2012)	22	12 long-stemmed humeral component that bypassed the fracture 8 resection of the proximal humerus with endoprosthetic replacement 2 clamshell prosthesis	42 (12–91)	75 (61–90)	All anterolateral approach	12 very satisfied, 3 satisfied and 3 dissatisfied
Carlos García-Fernández et al <sup>16</sup> (2015)	7	5 ORIF 1 patient got plate+ strut allograft+ cerclage wires 2 patients got cerclage wires only 1 patient got plate+ cerclage wires 1 patient got 2 lateral plates 1 revision: Long stem + cerclage 1 CONSERVATIVE TREATMENT	—	75.14 (59–83)	1 posterior approach 5 anterolateral approaches 1 conservative	All unions 2 radial nerve palsy (1 pre-op and 1 post-op)
Jaeger et al. <sup>18</sup> (2017)	17	13 ORIF 4 REVISIONS	—	—	All anterolateral approach	All healed, except 1 ORIF; no intra or postoperative complication

(continued)

Table 1. (continued)

Study	N° of Fractures	Treatment	Mean Follow-Up (Range)	Mean Patient Age (years)	Surgical Approach	Results
Thes et al. <sup>19</sup> (2017)	6	6 women (4B1 and 2C1 according to worland) Bicortical onlay strut allograft as a “sarcophagus,” stabilized with cerclage wires	12 ± 2	74.3 ± 10.9	All anterolateral approach	All healed after 6 months with no fracture recurrence 1 radial nerve palsy, healed in 6 month VAS 4.2±2.1 Absolute constant score: 25.1±8% Weighted constant score: 29.6±15.5% ASES 46.5±14.3%
Scoch et al. <sup>20</sup> (2017)	5	4C and 1B (according to worland) 5 ORIF with a 4.5 mm large fragment plate and a 3.5 mm attachment plate	12	77	All anterolateral approach	All healed with bony union at 3.7 No complication No reoperation
Rollo et al. <sup>7</sup> (2020)	30	15 ORIF 15 ORIF + strut allograft	16 ± 4	76.87 ± 11.9	All anterolateral approach	Intraoperative fracture: ORIF: 0 ORIF+SA: 1 Postoperative fracture ORIF: 1 ORIF+SA: 0 CSS at 12 months ORIF: 66.7 ORIF + SA: 66.7 OSS at 12 months ORIF: 63.4 ORIF: 63.5
Our experience	18	11 C and 7 B2 (according to Worland classification) All ORIF + SA + cerclage wires. Plate put on the posterior cortex and strut on the anterior I	12	75.3	Posterior approach	2 cases of radial nerve stupor, healed at 3 months all healed at a mean 4.2 months no infection strut allograft osteointegration in 6/18 cases At 12 months average active shoulder flexion: 88° -active abduction: 73° active external rotation: 22° average ASES score: 73 average VAS score: 1.1

at a mean follow-up of 15 months, except 1 in the ORIF group. No intra or postoperative complication was seen.

Thes et al.<sup>19</sup> wrote about a 6-patients case report, in which they used bilateral onlay strut allograft as a “sarcophagus” blocked with 4 cerclage wires. According to Worland classification, there were 4 B1 type fractures and 2 C1 fractures. All the patients were women, and the mean age was 74.3 ± 10.9 years. All the fractures healed at a

mean time of 6 months with no fracture recurrence at a 12 month follow-up. There was a case of radial nerve palsy, which completely healed in 6 months. The mean ASES score at the last follow-up was 46.5 ± 14.3%, while the weighted Constant score was 29.6 ± 15.5%.

At the end, Rollo et al.<sup>7</sup> analyzed a cohort of 30 patients with periprosthetic humeral fractures, and divided them into 2 groups, depending on the treatment they received: 15

were treated with plate and screws (PS), and 15 with plate, screws and strut allograft (PSS). According to Worland classification, 9 were B1, 11 were B2, 2 were B3 and 8 were C type fractures. The mean age and the mean follow-up were similar in the 2 groups. Intraoperative fracture occurred in a case in the PSS group, while there was a post-operative fracture in the PS group. The Constant-Shoulder score at 12 months follow-up was 66.7 for the PS group and 66.7 for the PSS group, while the Oxford Shoulder score was 63.4 for PS group and 63.5 for PSS group.

**Table 1**-Reintervention for periprosthetic humeral fracture in the Literature.

## Discussion

Surgical treatment of periprosthetic humeral fractures following a shoulder arthroplasty remains a hard challenge for every surgeon. Based on the assumption that the treatment decision must consider fracture's location, displacement and local bone quality,<sup>21</sup> treatment modalities vary from conservative treatment to ORIF and revision arthroplasty.

In case of nondisplaced or minimal displaced fractures with transverse or spiroid morphology, conservative treatment may be indicated, with a splint immobilization in neutral rotation or abduction, to avoid diaphyseal rotational malunion.<sup>22</sup> However, due to the high rates of nonunion<sup>8,10,23</sup> and the shoulder function deterioration because of the long period of immobilization, conservative treatment is not always an efficacious and feasible method of obtaining union of the fracture,<sup>24</sup> and may be indicated only in low functional requirement patients or in presence of severe comorbidities. For those reasons, surgical treatment is indicated as the gold standard in treating even these fractures.

Aim of surgical treatment should be functional recovery with respect to pre-injury activity level, minimizing complications.<sup>25</sup> Many of the treatment principles have been borrowed from experience in treating native proximal humeral fractures and from few published retrospective case series and expert opinions.<sup>13,16</sup> Tuberosity fractures should generally be repaired with transosseous sutures, FiberWire (Arthrex), or cerclage wires.<sup>3</sup> When performing a surgical procedure for fractures of the humeral shaft, if the humeral component is stable, the fracture can be treated with plate fixation. If the humeral stem is loose, it should be treated with revision to a long-stem humeral component and fracture fixation.<sup>16,18,26</sup> Open reduction and internal fixation may consist of plate and screw constructs, cerclage wires, and/or strut graft.<sup>7</sup> Cerclage wires or sutures carry a risk of circumferential stripping of soft tissue, osseous vascular compromise, and nerve injury during passage.<sup>3</sup> Identification of the radial nerve is always needed to allow

its protection when diaphyseal cerclages have to be performed.<sup>25</sup>

The method of osteosynthesis presented in this paper, based on the placement of the plate along the posterior humeral surface and the strut allograft in the anterior side, which is applicable only in case of a B or C type fracture according to Worland classification, could be a good option for several reasons. At first the triceps sparing technique would allow a faster and better return to activities, since the triceps muscle may help the rehabilitation process since the very first weeks of treatment, because of its integrity. As a second advantage, the posterior approach in these fractures is very easy to execute and allows a great view on the radial nerve, which represent the most important anatomic landmark in the periprosthetic humeral fracture surgery. At the end, the 3.5 mm LCP extra-articular distal humerus plate, together with strut allograft, guarantees a better stability compared to the lateral plate and may decrease sensitively the possibility of nonunion or refracture.

This study, however, presents several limitations, including a small number of patients treated with the same technique but with different types of fracture. Moreover, it has been used 2 different types of RTSA (cemented and uncemented). At the end, there is no comparison between our method and the other papers reviewed, mostly due to the fact that there is not a uniformity in treatment devices and functional score used; the assessment of clear guidelines for the surgery of periprosthetic humeral fractures could help in future to help defining the superiority of a treatment over the others.

## Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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