Surgical Fixation of Distal Periprosthetic Humerus Fractures using a Distal Femoral Locking Plate: Surgical Technique and Report of Three Cases

Abstract
Periprosthetic fractures about the humerus are a rare but difficult complication of shoulder arthroplasty, occurring in up to 3% of cases. Depending on the fracture pattern, open reduction and internal fixation (ORIF) may be used to definitively treat these injuries. This article demonstrates a new technique that uses a distal femoral locking plate to maximize bony fixation of such periprosthetic humeral fractures. Between November 2008 and July 2016, three patients with periprosthetic humerus fractures were treated with open reduction internal fixation using a distal femoral locking plate. All patients were followed until radiographic union. Fractures occurred at a mean of 5.2 years after arthroplasty (range, 1 to 7.5 years). Two of the fractures were classified as Wright-Cofield Type C and one fracture was Wright-Cofield Type B. Surgical fixation was performed at a mean of 6 days after fracture. All were treated with a fixed angle distal femoral locking plate. Healing was confirmed radiographically for all three patients at a mean of 11.8 months (range 3 to 28.5 months). No patient required reoperation. Obtaining adequate bony fixation around periprosthetic humerus fractures remains challenging. The use of a distal femoral locking plate may be helpful in patients with long stem prostheses which require increased distal fixation.
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Introduction

Periprosthetic fractures have been reported to occur in between 0.6-3% of shoulder arthroplasties [1]. Nonsurgical treatment is often reserved for fractures that are far distal to the prosthesis or without significant proximal displacement [1, 2]. Meanwhile, revision arthroplasty surgery is often required in the setting of a loose humeral component. Fractures that are not amenable to these treatment options and require internal fixation are challenging to treat as the prosthetic stem occupies the intramedullary canal of the humerus and limits fixation proximally [2-4].
Open reduction and internal fixation (ORIF) is considered for those patients with a well-fixed stem who fail non-operative management or present with a fracture pattern not amenable to non-operative management. Fractures about the tip of the stem have been shown to have a higher rate of non-union, leading some authors to consider early surgical fixation in these patterns as well [5, 6]. ORIF is desirable due to simultaneous humeral bone preservation and restoration of shoulder function. Various operative techniques have been described to supplement fixation for the treatment of periprosthetic humeral fractures [2, 7-9]. Most commonly, surgeons use plate and screw constructs to secure the fracture. Proximally, this may require supplementation with unicortical locking screws and/or cables to achieve adequate stability [2, 7]. Allograft struts and extension plates have also been described to help augment proximal fixation [8, 10]. In the setting of a long-stemmed prosthesis, distal fixation may be challenging, with little bone stock available to accept screws. We present a case series of patients with periprosthetic humerus fractures treated with a new technique utilizing a distal femoral locking plate.

Methods

This case series was conducted following institutional review board approval. All patients treated for a periprosthetic humerus fracture between 2002 and 2016 were identified using current procedural terminology (CPT) codes and ICD-10 (international classification of diseases, tenth revision) codes. Three patients surgically treated with a distal femoral locking plate were identified (Tables 1). No patient with this construct was excluded. Clinical records were reviewed for patient demographics, initial type of arthroplasty, mechanism of injury, and time from arthroplasty to fracture and fracture to ORIF. Preoperative radiographs were assessed to classify the fracture pattern according to the Wright-Cofield Classification. In this classification system, a Type A fracture is centered at the tip of the stem with proximal extension more than 1/3 of the implant length, a Type B fracture is centered at the tip of the stem, and a Type C fracture is located distal to the tip of the stem. All included patients were seen post-operatively at two weeks, six weeks, and three months. If fracture union was not appreciated within these time points, the patients were continuously followed until the time of union. The time to fracture union was recorded from chart notes and radiographic imaging. All patients were followed until radiographic union was obtained.

Surgical Technique

The patient is placed in the lateral decubitus position with the fractured arm supported by a bone foam block on a plexiglass board. A midline posterior incision is made from the olecranon proximally. A triceps splitting approach is used, but a Gerwin-Hotchkiss approach can be used for greater proximal exposure if needed [11]. The radial nerve is identified, mobilized, and protected. The fracture is identified and exposed, taking care to preserve the periosteum immediately adjacent to the fracture site. Fracture ends are debrided to fresh bone ends. The fracture is then reduced. When possible, a 2.7 mm lag screw is placed across the fracture. A 4.5 mm LCP condylar distal femoral locking plate (Synthes, West Chester, PA) is applied.

A right distal femoral locking plate is used for a left elbow, and a left sided plate for a right elbow. This allows the flare of the distal plate to sit posteriorly over the capitellar bone. Its distal central curve is positioned just superior to the olecranon fossa, allowing the distal flares to extend down over the medial and lateral columns. Screws are placed sequentially in the distal and proximal segment as the fracture pattern and intramedullary prosthesis allow. The distal 7.3 mm locking screw must be measured and shortened with a metal cutting burr, as the shortest screw in this system is 50 mm. Proximally, if the humeral stem does not allow for sufficient screw fixation, cerclage cables are used for supplementation. After completion of bony fixation, the wound is irrigated and closed in routine layered fashion.

Post-operatively, a bulky dressing is applied and the arm is placed into a simple sling. The sling is continued for two weeks. After two weeks, the patient is allowed to use the arm for activities of daily living, with a one-pound weight lifting restriction. Patients are instructed on a home exercise program that includes elbow flexion and extension as well as shoulder forward elevation and external rotation. At six weeks, rotator cuff strengthening is prescribed if necessary. Patients are allowed to return to full activity at 3 months, or when fracture union is confirmed.

Table 1. Patient Information

Case	Age	Medical Comorbidities	Type of Arthroplasty	Mechanisms of Injury	Other Injuries	Wright-Cofield Classification	Time from Arthroplasty to Fracture (years)	Time from injury to surgery (days)
1	67	Systemic Lupus Erythematosus	Anatomic Arthroplasty	Fall from Standing	none	Type B	1	8
2	75	Factor V Leiden Thrombophilia	Hemi Arthroplasty	Fall from standing	Complete Radial Neuropathy	Type C	7	5
3	69	Type II Diabetes Hypertension	Hemi Arthroplasty	Fall from Standing	none	Type C	7.5	5

Results

Three female patients with a mean age of 70 (range, 67 to 75 years) underwent surgical fixation of a periprosthetic humeral shaft fracture using a distal femoral locking plate (Fig. 1-6). All fractures occurred secondary to a mechanical fall from standing height. The mean interval between index arthroplasty and surgical fixation was 5.2 years. One patient sustained a radial nerve palsy that was documented preoperatively. Fractures occurred about one anatomic total shoulder arthroplasty and two hemiarthroplasties. Two of the fractures were classified as Wright-Cofield Type C and one fracture was Wright-Cofield Type B. Surgery was performed at an average of six days after the fracture.

Radiographic bony union was confirmed at a mean of 11.8 months (range, 3 to 28.5 months). One patient fell early in the post-operative period and sustained an additional fracture within the plate construct. This was identified at her 4-month post-operative visit where healing callus was noted about the new fracture line. Following union, the patient who sustained a preoperative radial nerve palsy was referred to a hand surgeon for evaluation of the radial nerve, who, as of four months post-operation, wanted only to observe the injury. No patient required reoperation.

Discussion

Periprosthetic fractures can be managed utilizing a number of described techniques [2,7-9]. In older patients with osteoporosis, obtaining adequate bony fixation can be challenging. This is increasingly difficult in the setting of a long-stemmed prosthesis with a distal fracture. The technique described in this a series offers the patient and treating surgeon many advantages. The use of a distal femoral locking plate allows the surgeons to obtain increased bony fixation distally without sacrificing proximal fixation, covers both medial and lateral columns with a single plate, and obtains strong fixation using the 7.3mm bolt in the center of the plate. There is also theoretical increased protection to the distal humerus for patients who are at risk of subsequent falls. This was observed in this series with the patient who sustained a fall following periprosthetic ORIF; the hardware appeared to protect the humerus allowing the new fracture line within the construct to heal without further intervention. Rigid fixation also allows for early range of motion and return to

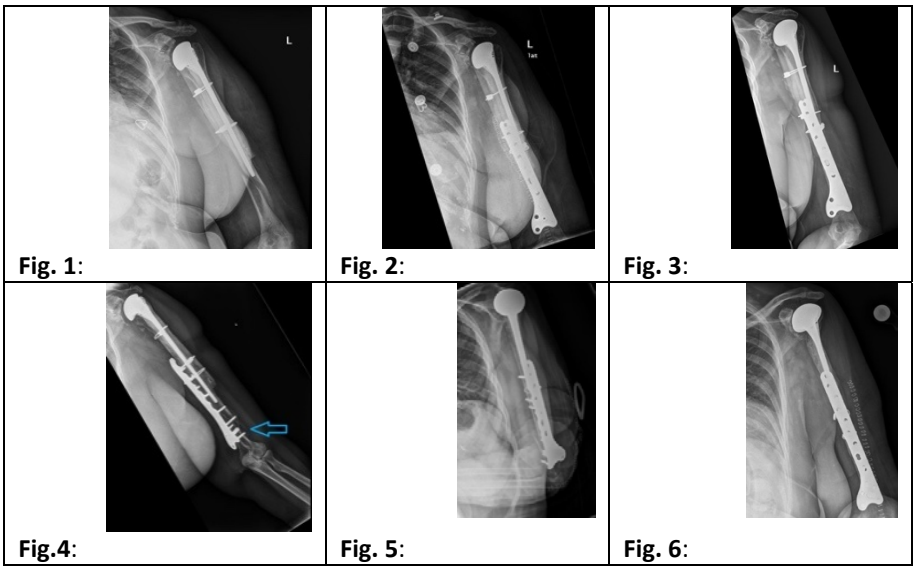

Fig. 1: Figure 1 shows a pre-operative AP Radiograph of Patient #1.
Fig. 2: Figure 2 shows a post-operative AP Radiograph of Patient #1 at two weeks.
Fig. 3: Figure 3 shows post-operative AP Radiograph of Patient #1 at 16 weeks, which shows a new fracture with callous formation within level of the plate.
Fig. 4: Figure 4 shows a post-operative AP Radiograph of Patient #1 at 28 weeks with an arrow showing callus formation.
Fig. 5: Figure 5 shows a post-operative AP Radiograph of Patient #2 at 3 weeks.
Fig. 6: Figure 6 shows a post-operative AP Radiograph of Patient #3 at 2 weeks.

functional status. Additionally, by extending the plate distally, there is no stress riser created in the supracondylar region of the humerus. One disadvantage of this technique is that it requires exposure of the radial nerve in order to safely place the plate on the posterior aspect of the humerus. Additionally, the hardware may be felt over the distal aspect of the elbow in patients who are particularly thin. Lastly, the large minimal screw length of the distal locking screw requires surgeon modification of the screw to accommodate the smaller size of the humerus.

The results of this series of cases are similar to other series which have assessed the effectiveness of various surgical techniques for the treatment of periprosthetic humeral fractures. A case series of six patients treated with broad 4.5 mm locking compression plates, cable wires, and strut allograft augmentation showed a mean time to union of 5.4 months (range, 4 to 6 months)[8]. Another series of seven patients treated with locking plates, cable wires, and screws showed a mean time to union of 5.1 months (range, 4 to 6 months) [12]. At first glance, these series seem to have a mean time to fracture union that is nearly half of that seen in our series. However, there is a likely explanation for this discrepancy.

One of the three patients in our case series did not have a confirmed union until 28.5 months after her surgery, which significantly increased the mean time to union for the series. Between the time of her two month and four month follow up appointments, this patient sustained a fall that resulted in a new injury with pain symptoms concerning for a fracture within the span of the plate construct (Fig. 3). It is possible that this injury delayed the healing of the initial periprosthetic fracture. Because the new injury did not require any intervention, the patient did not have another appointment until her two-year check-up, at which point union was confirmed. A more frequent follow up schedule would have likely resulted in an earlier confirmation of fracture healing. In contrast, the mean time to union for the other two patients in this series was 3.5 months.

This case series is limited by the small number of cases and the abnormally high time to union for one of the three cases, the latter being likely result of both the new fracture sustained during the normal recovery period and the timing of follow up appointments. The main strength of this study is that it demonstrates the potential effectiveness of a novel treatment technique. Longitudinal follow up of patients demonstrated healing, confirmed radiographically, for all cases. Additionally, the time to union was generally similar to other techniques used to treat periprosthetic humeral fractures.

Conclusion

The use of a distal femoral locking plate for the treatment of periprosthetic humeral fractures can be an effective technique to increase distal bony fixation, which remains a challenge for treating surgeons faced with long stemmed prostheses and distally projecting fractures. Challenges are magnified in patients with decreased bone stock and those with osteoporosis. This construct offers the unique ability to obtain distal humeral fixation while simultaneously protecting the remaining distal humerus bone stock against future falls.

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