Long-stemmed Hemiarthroplasty with Cerclage Wiring for the Treatment of Split-Head Fractures of the Proximal Humerus with Metaphyseal Extension: A Report of 2 Cases

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Abstract

Introduction: Complex fractures of the proximal humerus with splitting-head component and metaphyseal propagation are very rare injuries that are difficult to treat. Preservation of the humeral head is always considered except in cases with severe comminution and compromised vascularity where shoulder hemiarthroplasty is an alternative option.
Case Report: We present two male patients, 57- and 62-years-old who sustained such a complex proximal humeral fracture after a high-energy injury. They both managed with long-stemmed shoulder hemiarthroplasty and cerclage wiring of the metaphyseal area. They both demonstrated good clinical and radiological outcome at 32- and 24-months postoperatively.
Conclusion: We report the functional and radiological outcomes of two cases of a rare proximal humeral fracture's pattern - combination of splitting-head and metaphyseal comminution – that were managed with long-stemmed hemiarthroplasty and cerclage wire and demonstrated good midterm clinical outcome.

Keywords

Proximal humeral fracture, split head, metaphyseal comminution, cerclage, shoulder hemiarthroplasty

Introduction

Proximal humerus fractures (PHF) are the third most frequent osteoporotic fractures in adults after hip and wrist fractures and according to a recent decennial study in 98,770 individuals demonstrate not only an increased prevalence (30-40%) but also an increased proportion (12-17%) of surgically treated patients.[1,2] Their global incidence varies between 4–10% of all fractures, are more common in females (60-70%) and approximately 85% of them occur in individuals older than 50 years-old.[3,4] Complex PHF affect mainly elderly people after simple fall or younger adults involved in high-energy injuries and their incidence is also increasing worldwide due to the global ageing of population and to the changes in modern lifestyle; in some series these more severe fractures account for almost 13–15% of all PHF.[5–7]

Splitting-head fractures are rare, comprised less than 5% of all PHF and are defined as the proximal humerus fractures in which the humeral head is split into more than one fragment with the fractured fragments measuring more than 20% of the articular surface; their usual cause is a direct fall on to the shoulder with impaction of the head against the glenoid and they are often associated with dislocation or subluxation of the glenohumeral joint and with fractures of metadiaphyseal area.[8–12] In contrast to historical reports, isolated head-split fractures do not always predispose to humeral head ischemia or even avascular necrosis (AVN).[13–15] Gavaskar et al.[16] believe that the risk factors

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for AVN of split-head fractures include a complex fracture pattern, the presence of anterior dislocation, the associated soft tissue injury, and the choice of the surgical approach (deltopectoral). Scheibel et al.[15] proposed recently, a new classification of split-head fractures (SHF) into 4 types; type I: SHF with the fracture line within the posterior half of the humeral head with the larger head fragment located anteriorly, type II: SHF with the fracture line within the anterior half of the humeral head with the larger head fragment located posteriorly, type III: SHF with a loose or free-floating central fragment and type IV: comminuted SHF. Treatment options of these difficult fractures remain controversial depended mainly on the fracture pattern, metaphyseal comminution, tuberosity involvement, presence of dislocation, bone quality, age, activity level, and surgeon's preference.[17–20] Considering the difficulty to determine the extent of vascular damage and admeasure the existing probability of creeping revascularization, a joint-preserving treatment is always recommended in young patients < 50 years-old, regardless of the complexity of PHF.[16,21] Hemiarthroplasty (HA) or reverse total shoulder arthroplasty (RTSA) is reserved for fractures with severe comminution, marked articular damage, associated dislocation, older patients or a pre-existing osteoarthritis or cuff tear arthropathy.[22–24]

Addressing the issues of proximal humerus fractures with compromised humeral head and severe metaphyseal comminution, we present two cases treated with long-stemmed hemiarthroplasty and additional stabilization with cerclage wires.
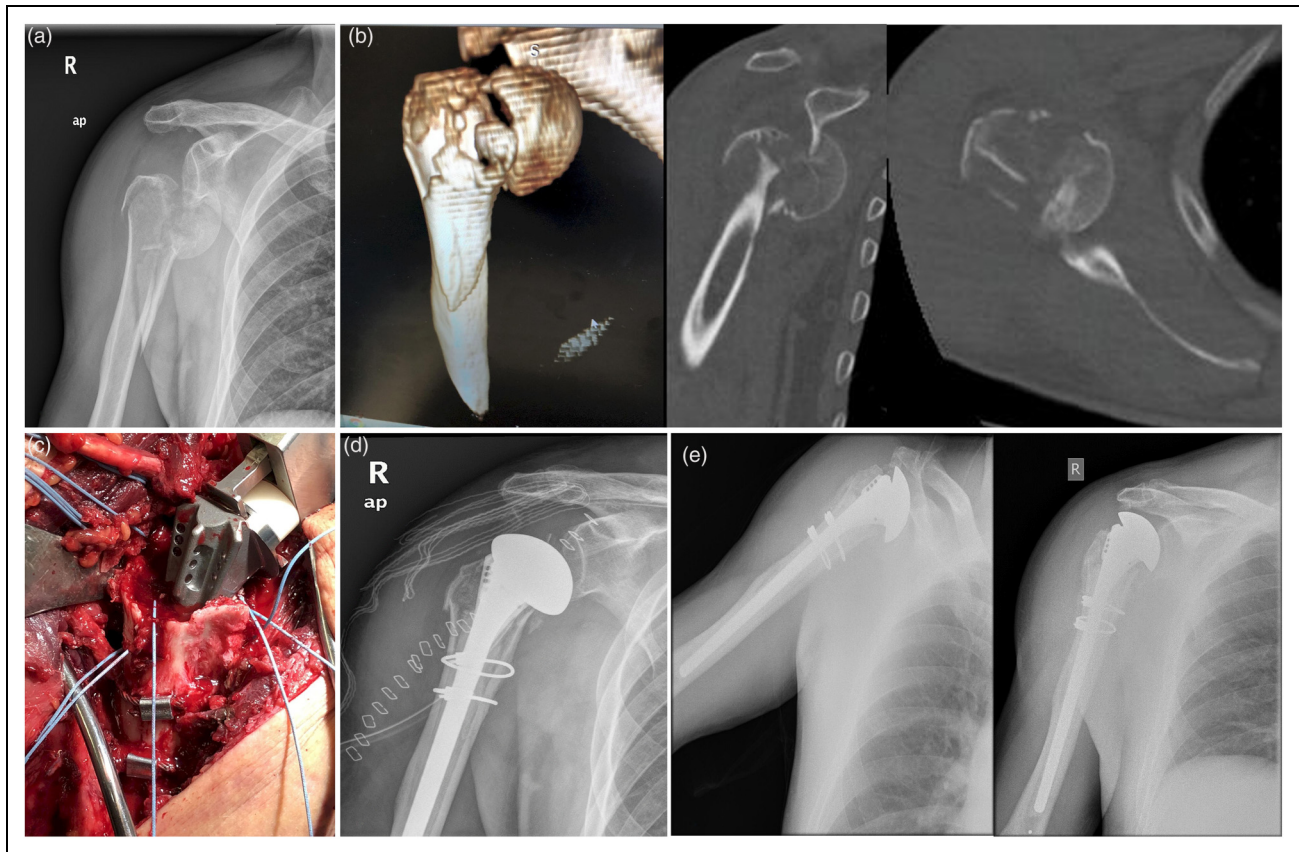
Case Reports

Case 1

A 62-year-old male was transferred from another hospital after sustained a closed injury to his right shoulder falling off a 3-meter-high roof in his arm. He had no other associated injuries and his past medical history was unremarkable except from heavy smoking and daily use of alcohol. On clinical examination there was an obvious deltoid sulcus, inability for passive range of motion due to pain but without any neurovascular compromise. Radiological examination revealed a locked anterior fracture-dislocation, type I splitting of the humeral head without adequate metaphyseal extension, severe metadiaphyseal comminution and fracture of the greater and lesser tuberosities (Figure 1a). The patient was unable to undergo further radiological imaging due to his discomfort and locked arm position; subsequent coronal and axial CT scans and 3D-CT reconstruction revealed the split head component and the severe metaphyseal comminution (Figure 1b). Within 24 h after the injury, the patient was operated under general anesthesia, in the beach-chair position via the extended deltopectoral approach. After preparation at the fracture site the humeral head was found impacted under the glenoid, having a

fracture at its midline without any remaining bony or soft tissue attachments. As the fracture was not amenable for fixation the humeral head was removed and kept for bone grafting. Significant metaphyseal comminution was noted including two large wedge fragments that were temporarily stabilized with Kirschner wires. The humeral metaphysis was fixed with 2 cerclage cables (Orthopaedic Cable System, DePuy Synthes, Solothurn, Switzerland) after inserting a trial humeral stem to act as temporary filler. The cables were positioned in the middle-third of the main metaphyseal fragment, 2 cm apart from each other, using the special curved passer; care was taking to remain as closed as possible to the bone for protection of the neurovascular structures. The cables were tightened loose initially to just hold the fragments in place. A long-stemmed cemented hemiarthroplasty (GLOBAL® FX Shoulder Fracture System, DePuy Synthes) was applied thereafter with appropriate height and version (Figure 1b). Regarding the height we aimed to apply the top border of the humeral stem at the level of the anatomic neck fracture flash with the medial calcar and also a ruler was used to measure the 5.6 +/- 0.5 cm pectoralis major tendon reference point (Figure 1c). Humeral version was then set at 20 degrees of retroversion by placing the arm in a neutral position at the side and using the prosthesis version rod. The long-stemmed implant was selected according to the general rule of by-passing the most distal aspect of the meta-diaphyseal fracture extension by a distance equal to at least twice the diameter of the diaphysis; the cemented stem was selected for extra stability and also to have the opportunity to tie tighter the cables with the cable tensioner when the cement was hardened. Just prior to cementation drill holes were placed on either side of the bicipital groove and four Number 5 non-absorbable Ethibond sutures were inserted through each for vertical tension-band fixation of the tuberosities (Figure 1c). Bone grafting from the extracted humeral head was applied to promote tuberosity healing. There was no evidence of rotator cuff tear. Postoperative x-ray showed appropriate height of the prosthesis and adequate tuberosities reattachment (Figure 1d); the shoulder was immobilized in a sling for 4 weeks and passive assisted exercises were initiated from the second postoperative day. The patient was followed up regularly in an outpatient basis and at his last follow up 24 months postoperatively, he demonstrated acceptable range of motion, with 170° of forward elevation, a Constant score of 86 points and good tuberosity healing (Figure 1e).
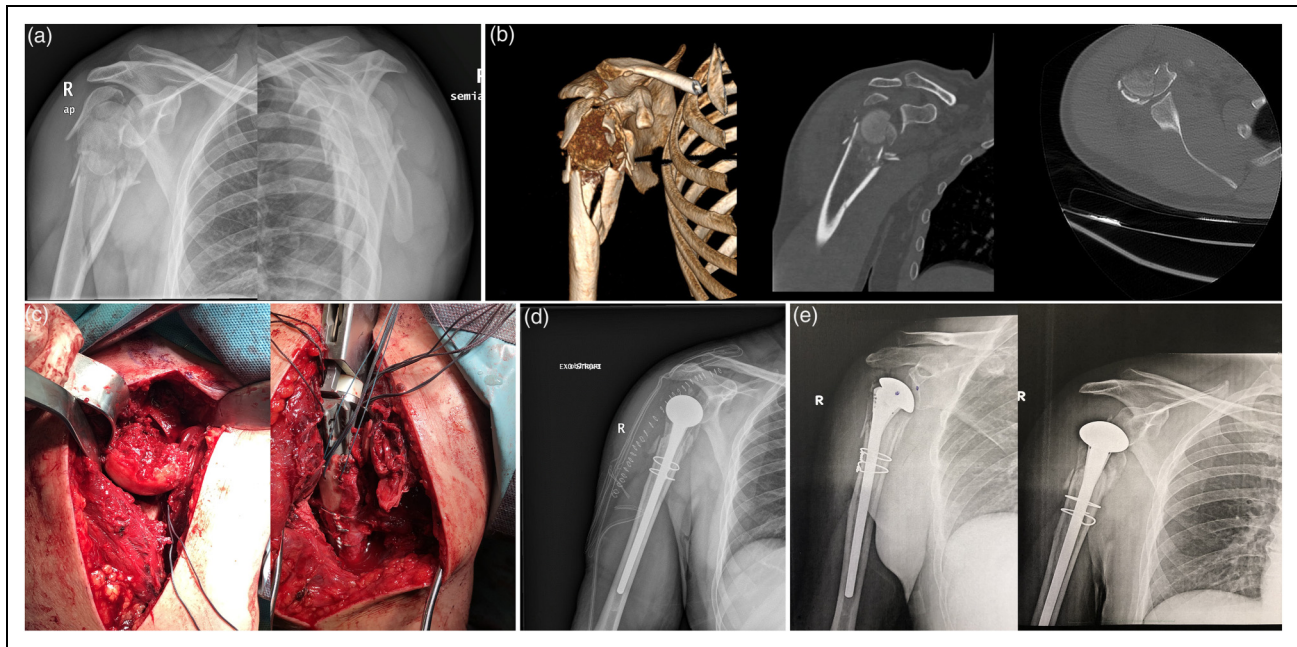
Case 2

A 57-year-old male was admitted to the hospital after a road-traffic accident with his bike, when he lost control in a slippery road and fell on his right shoulder, without any associate injuries. His past medical history was insignificant except from light smoking. On clinical examination he was unable

Figure 1. (a) preoperative x-ray of our first patient (62-years-old) showing a simple (type I) split head fracture with anterior dislocation and impaction of the humeral head underneath the glenoid; there is also severe metaphyseal comminution and associated fracture of both tuberosities. (b) coronal, axial and 3-D-CT scans showing the impaction of the humeral head under the glenoid and the split-head component, (c) intraoperative picture with the final implant in the appropriate height after metaphyseal fixation with cables – note the Ethibond sutures that were used for later tuberosities fixation, (d) postoperative x-ray showing good height of the prosthesis, tuberosities re-attachment and fixation of the metaphyseal area and (e) follow-up x-ray at 24 months showing good tuberosity healing without evidence of prosthesis migration.

to move his right shoulder, he had remarkable swelling and bruising in the area but without any evidence of neurovascular injury. Radiological examination revealed a type IV splitting-head fracture of the proximal humerus with severe metaphyseal comminution and displaced tuberosities (Figure 2a). Axial, coronal and 3D-CT reconstruction scans better revealed the split-head component (Figure 2b). The patient was operated the following day under general anesthesia in the beach-chair position via the extended deltopectoral approach. After preparation at the fracture site the humeral head was found splitted and multifragmented without any evidence of vascularity and was removed as a source of bone grafting later (Figure 2c). The tuberosities were displaced without evidence of rotator cuff tearing and were held apart with non-absorbable sutures. The metadiaphyseal area was severely comminuted, with three large butterfly fragments. A trial hemiarthroplasty stem was used as a temporary filler to fix the fragments to the diaphysis with 2 cerclage wires; cables were not available at that

time but we used the same technique of application using a curved suture passer at the mid-third of the main metadiaphyseal fragment. The wires were tightened loose as before and harder as soon as the cement was ready. A long-stemmed cemented hemiarthroplasty (GLOBAL® FX Shoulder Fracture System, DePuy Synthes) was applied thereafter with the appropriate height and version as has been described before (Figure 2c). The tuberosities were re-attached and bone grafting from the extracted humeral head was applied to promote tuberosity healing. Postoperative x-ray control showed good position of the prosthesis and tuberosities (Figure 2d); the shoulder was immobilized in a sling for 4 weeks and passive assisted exercises were initiated from the second postoperative day. The patient was followed up regularly in an outpatient basis and at his last follow up visit, 32 months postoperatively, he demonstrated excellent range of motion, with 175° forward elevation, a Constant score of 90 points and good tuberosity healing (Figure 2e).

Figure 2. (a) preoperative anteroposterior and semi-axial x-rays of the second patient (57 years-old) showing a complex (type IV) split head fracture of the humeral head with severe metaphyseal comminution and associated tuberosity fractures, (b) coronal, axial and 3-D-CT scans showing the complex meta-diaphyseal extension and the split-head fracture, (c) intraoperative picture with the avascular head fragment and the prosthesis in place just prior to tuberosities fixation; note the reconstruction of the metaphyseal area with cerclage wires, (d) postoperative x-ray showing tuberosities reattachment, correct height of the prosthesis and fixation of the metaphyseal area and (e) follow-up x-ray at 32 months showing tuberosities healing and no signs of prosthesis migration.

Both patients were consented to the proposed treatment and agreed to publish their data (x-rays and intraoperative photos). An institutional review board approval was obtained also (AΦ 123-12/9/2021).

Discussion

Split head fractures of the humeral head associated with severe metadiaphyseal fragmentation are extremely rare injuries and are challenging even for experienced shoulder surgeons. In isolated split-head fractures the decision making is depended on several factors including the age and demands of the patient, the type of the fracture (simple or complex), the expected viability of the humeral head and the degree of metaphyseal comminution and tuberosity displacement.[15,18,20] Minimal osteosynthesis with screws, standard anatomic locking plates and augmented techniques with low-profile hinged plates for medial calcar support have been proposed in an effort to preserve the viability of the humeral head in younger patients.[7,9–11,25] According to Gavaskar et al.[19] internal fixation of complex proximal humerus fractures can result in poor shoulder function and complications in a high number of patients; specifically, 8% nonunion proportion, 21% avascular necrosis, and 15% revision surgery. These authors suggested that a four-part fracture dislocation, absent of metaphyseal head extension and back-bleeding from the head, height of the fractured head segment < 2 cm,

and absence of capsular attachments to the head were independently associated with poor function and complications. Chesser et al.[9] presented 8 cases of splitting-head fractures of proximal humerus treated with open reduction and internal fixation presenting with a mean Constant score of 78 (31-100), with one case awaiting hemiarthroplasty and another one posterior stabilization. Peters et al.[12] reported an overall complication rate of 83% in split-head fractures (ORIF: 88%; RTSA: 75%; HA: 50%) with the most common complications following ORIF being humeral head osteonecrosis (42%), malunion of the lesser tuberosity (33%), and screw protrusion (29%), whereas all complications following RTSA were related to tuberosity problems. Jost et al.[26] reported that 10 of 11 head-split fractures treated with locking plate osteosynthesis showed malunion at follow-up, highlighting the general difficulty of achieving adequate reduction and stable fixation of these fractures. Gavaskar and Tummala[16] reported the outcome of 16 patients <55 years-old who underwent locked plating for humeral head–splitting fractures (5 simple and 11 complex); most of their complications were seen in complex fracture patterns including a nonunion rate of 20% and an AVN rate of 40%. They also reported one case of glenohumeral arthritis, one case of primary intra-articular screw placement, two cases of secondary articular screw penetration after AVN and secondary collapse, and one patient with symptomatic impingement.

Primary hemiarthroplasty or reverse shoulder arthroplasty must be considered in patients where a stable reduction is not feasible because of severe comminution, as in our cases, considering the goal to avoid poor outcomes and the necessity of subsequent revision surgeries after a failed osteosynthesis. Traditionally, hemiarthroplasty has been proposed for split-head fractures involving more than 45%-50% of the articular surface. Greiwe et al.[27] compared the outcomes of hemiarthroplasty for head-split fractures (n = 8) with those with standard three- or four-part fractures of the proximal humerus (n = 22) and showed an average active forward flexion of 138°, 12.5% complication rate and 0% of revision surgery at a mean follow-up period of 3.6 years. Antuña et al.[28] reviewed 57 patients with complex PHF treated with hemiarthroplasty; 5 patients among them had head-splitting fractures and for unknown reasons demonstrated better forward flexion (146°) in comparison to the other fracture types (~ 100°). Spross et al.[29] compared locking plate fixation (n = 22) versus hemiarthroplasty (n = 22) for displaced Neer type VI PHF (3- and 4-part fracture-dislocations, impression fractures and split head fractures) and reported similar clinical outcome but 63.6% rate of complications (avascular necrosis and screw cut-outs) and 45.4% rate of revision surgery for the plate group in contrast to only 4.5% rate of revision surgery for the hemiarthroplasty group. Other reports on split-head or complex long segment fractures in the elderly are in favor of reverse shoulder arthroplasty as a primary treatment option.[8,24] Garofalo et al.[8] used a long-stemmed cemented RSA prothesis and cerclage wires to reconstruct the metaphyseal area as we did in our cases. Hemiarthroplasty or reverse shoulder arthroplasty in complex or split-head fractures with metaphyseal comminution is a challenging technique, as it requires to restore the correct length of humerus. The aim is to position the top border of the humeral stem at the level of the anatomic neck fracture at the level of the medial calcar but in cases of disturbance of calcar's continuity, the 5.6 +/- 0.5 cm pectoralis major tendon reference is a reliable landmark.[30] With a diaphyseal reamer inserted into the medullary canal of the largest possible diameter, the metaphyseal fracture fragments are reduced and the cerclage wires/cables are provisionally tightened to hold these fragments in position; when the cement is cured the wires are further tightened and the tuberosities are reattached to the predrilled holes in the metaphysis. We were able to demonstrate good functional outcome in both of our patients treated with this technique.

Conclusion

The functional and radiological outcomes of two cases of a rare fracture's pattern - combination of splitting-head and metaphyseal comminution – that managed with long-stemmed hemiarthroplasty are presented and demonstrated good clinical midterm outcome. Well-designed series of cases and particularly prospective, randomized controlled studies are required to investigate further the outcomes and effectiveness of hemiarthroplasty in proximal humerus fractures with severe metaphyseal comminution in middle age population.

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