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Plate fixation for management of humerus fractures

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ABSTRACT

Proximal humerus, humeral shaft, and distal humerus fractures are all common adult fractures, and often occur in older patients. While the treatment of proximal humerus fractures remains controversial, certain fractures benefit from plate fixation such as fracture-dislocations and head-split fractures. When plate fixation is chosen, anatomic reduction and restoration of the medial calcar are important for successful results. Further research is required to minimize complications and determine the optimal surgical candidates for plate fixation. Humeral shaft fractures are generally treated non-operatively. However, certain shaft fractures warrant plate fixation, such as open fractures, those with associated forearm fractures, and those in poly-trauma patients. Choice of surgical approach and plate depends on the location and type of the fracture. The majority of intra-articular distal humerus fractures should be treated with plate fixation. Dual plating is generally accepted as the gold standard treatment, while the optimal surgical approach and plate configuration requires more research.

Introduction

Humerus fractures comprise approximately 8% of all adult fractures, and their incidence increases with age [1]. As such, comorbidities and bone quality can complicate clinical decision-making. These injuries represent a significant burden to the patients themselves, as well as the healthcare system. Humeral fractures can involve the proximal, shaft, or distal aspect of the bone, and management depends on the location of the fracture. The most common humeral fracture occurs in the proximal humerus. Accounting for approximately half of all humerus factures, these injuries are a common fragility fracture in older adults and remain one of the most controversial orthopaedic trauma injuries to treat. While there is more consistent evidence surrounding the management of humeral shaft and distal humerus fractures, there are still many issues to consider regarding optimal treatment. In all three humeral fracture types, open reduction and internal fixation (ORIF) is the most common surgical intervention. The objective of this paper is to summarize the fracture types most amenable to plate fixation, as well as challenges and considerations associated with each fracture type.

Proximal humerus fractures

Representing the third most common fragility fracture in older adults, proximal humerus fractures are increasing in prevalence, and many clinical issues have yet to be clarified. Most proximal humerus fractures occur in patients above the age of 50 years, after a ground level fall. Due to the complexity of the shoulder joint, many factors influence functional recovery, including fracture type, displacement, patient age, bone quality, functional demands, pre-injury shoulder function and patient comorbidities. As such, there is significant controversy surrounding the management of these injuries. While the majority of proximal humerus fractures are treated non-operatively, several operative treatment options exist. The most common operative procedure is open reduction and internal fixation with locked plating. Unfortunately, there are no undisputed set of indications for surgical treatment, and it remains unclear as to which fractures consistently benefit from plate fixation. Traditionally, indications for plating included displaced fracture types according to the Neer classification system [2]. However, the Neer classification system has been shown to have poor inter- and intra- rater reliability [3]. This is also the case with other classification systems that have been developed for proximal humerus fractures. As such, while "fracture type" may be a traditional indication for surgery, these are not consistently reported between studies or surgeons.

Recently, increasing evidence from randomized controlled trials suggests that non-operative treatment offers comparable functional

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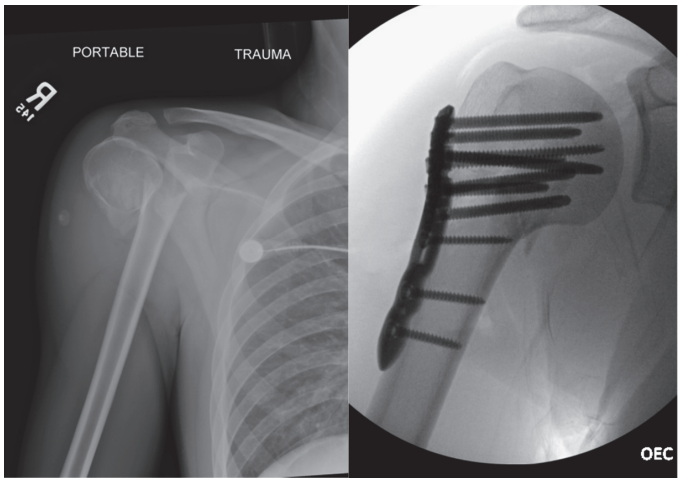

Fig. 1. Proximal humeral fracture in a 20-year-old male poly trauma patient with severe displacement, treated with open reduction and internal fixation with a locking plate.

results to operative treatment for even displaced fractures, while complication rates for ORIF still range up to 30% [4]. However, these randomized trials have had small sample sizes, and do not include all fractures. For example, the most recent and largest randomized trial comparing operative to non-operative treatment excluded patients with fracture dislocations, head-split fractures, fractures with no surgical neck involvement, and fractures for which there was a "clear indication for surgery" [5]. This likely indicates there are specific fracture types that may benefit from surgical management. Thus, the focus of research should shift from comparing different treatment modalities, towards identifying specific patients and fractures that would benefit from surgical intervention.

Fractures which have been well-documented to have poor outcomes following non-operative treatment include: fracture dislocations, head-split fractures, varus angulation/displacement, and significant/complete head-shaft displacement (Fig. 1) [6]. In the older patient, such fractures may benefit from proximal humeral replacement over plating, due to a higher risk of fixation failure. However, plate fixation is the treatment of choice for younger, more active patients [7].

Plate types

Prior to the introduction of locking plates, internal fixation was performed using a variety of implants, including tension-band wiring, trans-osseous suture fixation, and semi-tubular, buttress and cloverleaf plates. However, locking plate fixation may be more advantageous for osteoporotic bone [8]. When performing locking plate fixation, the insertion of inferomedial "calcar" screws has been shown to decrease varus displacement and provide better functional outcomes [9]. At present the use of polyaxial screws have not shown to have significant benefit compared to monoaxial screws [10].

Approach

Open reduction and internal fixation of proximal humerus fractures can be achieved through a delto-pectoral, or a minimally invasive deltoid-splitting approach. While the delto-pectoral approach is extensile and the most commonly used approach, the deltoid-splitting approach was proposed to minimize extensive soft tissue trauma and allow better access to the posterior aspect of the humeral head, and especially the greater tuberosity. However, a recent randomized trial comparing the two approaches identified no difference in complication rates, functional scores, or re-operations between the two groups [11].

Considerations

As a common osteoporotic fracture, the quality of bone must be considered. While locked plating has been shown to provide superior strength to conventional plating, there is still a risk of plate failure, intra articular screw penetration, screw cut out, or peri-implant fractures. Anatomic reduction is also important to reduce the risk of fixation failure. Care should be taken to restore medial support to the calcar, as this helps maintain reduction [12], and the use of a "calcar" screw is essential in preventing varus displacement (Fig. 1). The plate should be placed inferiorly enough to avoid impingement and aid in proper screw placement. Bone grafting can be used to improve outcomes in fractures with significant impaction and assist healing. A minimally invasive injectable graft has been shown to result in lower complications in one small randomized trial [13]. In elderly patients with osteoporotic bone and low functional demands who meet the criteria for surgical intervention, arthroplasty may be indicated.

Complications

Unfortunately, complication rates following ORIF have remained high. Reported complication rates two years following ORIF for proximal humerus fractures have ranged from 20–60% [14]. The most common complications following proximal humerus plating are: screw cut out and intra articular screws, tuberosity displacement or non-union, impingement, rotator cuff lesions, malunion or non-union, secondary displacement, osteonecrosis of the humeral head, posttraumatic osteoarthritis, screw loosening, heterotopic ossification, infection, and implant failure [14].

Risk factors for complications following ORIF for proximal humerus fractures include fracture-dislocations, smoking, obesity, increasing age, and comorbidities [15,16]. Specifically, risk factors for osteonecrosis include fracture-dislocation, disruption of medial hinge (calcar), and short metaphyseal head extension (<8 mm) [17].

Risk factors for screw cut out include increasing age, non-anatomic reduction of the calcar, fracture-dislocation, fracture type AO/OTA 11-C2 (impacted fracture with marked displacement) [18].

Conclusions

Although there remains controversy among surgeons and researchers regarding which proximal humerus fractures benefit from operative treatment, there is some consensus for surgery over non-operative treatment for fracture dislocations, head-split fractures and fractures with significant head-shaft displacement. Where ORIF is performed, anatomic reduction, and medial support may improve outcomes. Nevertheless, complication rates following ORIF of proximal humerus fractures remain high, and more research is required to optimize the treatment of these injuries. Elderly patients with such fractures, who have osteoporotic bone or are lower demand, perform poorly with ORIF, and may benefit from arthroplasty instead.

Humeral shaft fractures

Humeral shaft fractures account for up to 3% of all orthopaedic injuries. While overall they are evenly distributed between males and females, they do have a bi-modal distribution with the majority of high-energy fractures occurring in young males ages 21–30, and low-energy fractures occurring in older women, ages 60–80 years. Unlike proximal humerus fractures, the OTA/AO classification of humeral shaft fractures has moderate inter-observer reliability [19]. The most common fracture type is type A (simple, including spiral, oblique or transverse fractures), followed by type B (including spiral wedge, bending wedge or fragmented wedge), and type C (complex,