Open Distal Humerus Fractures
Review of the Literature

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Abstract

Fractures of the distal humerus can be difficult to treat due to the periarticular nature of these injuries and the complexity of the elbow joint. Although anatomic and timely repair of the distal humerus with meticulous handling of soft tissues and appropriate postoperative therapy all help to optimize results, an open fracture presents other challenges that may limit successful outcomes in spite of these measures. Open fractures have been found to affect younger males involved in high-energy injuries, as well as older, osteoporotic females involved in lower energy situations. Successful management of these injuries requires urgent and aggressive soft tissue management, skeletal stabilization, and treatment of neurovascular insult (if applicable). This article presents a review of the current literature available concerning the epidemiology, assessment and examination, treatment options, complications, and outcomes of patients with open distal humerus fractures.

Fractures of the distal humerus can be difficult to treat related to the periarticular nature of these injuries and the complexity of the elbow joint. Anatomic repair of the distal humerus is essential in order to restore adequate function of the elbow, and thorough attention to postoperative therapies is essential to maximizing elbow range of motion. It is therefore understandable that when one is presented with an open distal humerus fracture, the difficulty of effective treatment and restoration of adequate elbow function can become even more complicated. In addition to the concerns regarding neurovascular compromise, soft tissue injury, bony loss, and infection, open fractures present challenges and controversies when one also considers the possible treatment options, strategies, and timing of surgery. Successful management of these injuries requires urgent and aggressive soft tissue management, skeletal stabilization (either through internal or external fixation), and treatment of neurovascular insult (if applicable). This article presents a review of the current literature available concerning the epidemiology, assessment and examination, treatment options, complications, and outcomes of patients with open distal humerus fractures.

Epidemiology and Incidence

Distal humeral fractures, both open and closed, are relatively rare fractures, comprising only about 2% of all fractures. In an epidemiological analysis performed in Edinburgh, Scotland, it was found that open distal humeral fractures made up approximately 2.7% of all open long bone fractures. This 6-year analysis revealed that the average age of an individual presenting with an open distal humerus fracture is 40.6 years of age, with 57.1% of the patients being male. High-energy injuries were the most common reason for these open fractures, as the study found that nearly 43% of the injuries were due to motor vehicle accidents. Due to this high-energy correlation, open distal humeral fractures would most likely be seen in younger individuals involved in higher energy mechanisms. Osteoporotic elderly females comprise another group of patients seen with these fractures. However, since these osteoporotic fractures result from lower energy mechanisms, they would most likely present with closed or less severe open fractures. Falls, which are the most common
mechanisms for osteoporotic fractures, account for 21.4% of the open distal humerus fractures.

Again, due to the higher mechanism of energy, open distal humeral fractures are associated with other musculoskeletal or systemic injuries. Patients with open distal humeral fractures had an average Injury Severity Score (ISS) of 10.9, and 50% of these individuals also presented with some other musculoskeletal injury. Additionally, distal humeral fractures tend to have a very complex morphology, as 85.7% of the fractures presented as AO type C. Therefore, treatment of these individuals must not only take into account the complexity of the open humeral fracture itself, but also the patient’s overall condition, as judged by the severity of any coexisting injuries.

Assessment and Examination
Due to the associated concomitant injuries, the initial clinical examination of a patient with an open distal humerus fracture must follow the standard Advanced Trauma Life Support (ATLS) protocols. Once the most life-threatening injuries are addressed and stabilized, more attention can be directed to the open distal humerus fracture.

In addition to a detailed examination of the open fracture itself and associated soft tissue injury, careful investigation of any neurovascular injury must also be undertaken. This serves as a basis of determining the extent of soft tissue injury and to document the baseline neurovascular status. Additionally, any vascular compromise must be identified and addressed promptly, with consultation with the vascular surgeons and identification of the extent of the injury with angiography as required.

The degree of the open fracture, based on the Gustillo and Anderson classification, helps to guide treatment decisions and strategies. Depending on the severity of the soft tissue injuries, the experience of the surgeon, the availability of the implants, and the condition of the patient, the treating physician may choose between definitive fixation as compared to delayed fixation with external fixation (in a damage control orthopaedic manner).

The traction views taken in two planes may also be very informative and aid with delineating the fracture fragments and the preoperative planning of the fracture. Radiographic views of the ipsilateral wrist and shoulder should be obtained to exclude any concomitant injury.

Despite the usefulness of the traction view, the computed tomography (CT) scan provides more detailed information regarding the fracture personality that could be easily missed from the plain films. In addition to determining the preoperative characteristics of the fracture, the two-dimensional CT will allow for viewing of the fracture in several planes, and three-dimensional CT reconstructions will allow for a more precise illustration of the anatomy and any bony fragments involved in the fracture. With these additional imaging techniques, the surgeon can formulate a more effective preoperative plan for surgical repair of the elbow.

Treatment Options

Nonoperative Treatment
Irrigation and debridement of the open wound followed by surgical fixation (or temporizing fixation) is necessary and highly recommended as soon as possible after the injury. However, emergent surgery may not always be a viable or feasible option, depending on the overall condition of the patient or the availability of the required treatment resources. If surgery cannot be safely or properly performed soon after presentation of the fracture, irrigation and debridement may be performed at the bedside in order to reduce the risk of infection. Of course, this is not an ideal situation, as it does not allow for a thorough examination of the fracture, nor does it provide an adequate sterile environment. However, if the incision and drainage (I&D) is completed at the beside, the arm should be splinted and the patient obtain adequate clearance for operative intervention.

Operative Treatment
If the patient is adequately stabilized soon after presentation, surgery to either temporarily or definitively fixate the open distal humeral fracture should be performed as soon as possible. Once in the sterile operating theater, the elbow wound must first be emergently irrigated and debrided to remove all contaminated and dead tissues. For type II and type III open fractures, serial I&Ds are recommended every 24 to 48 hours after the initial debridement until a clean surgical wound is ensured.

Once the initial I&D is completed, the actual treatment and management of the open fracture in the operating room will depend on the nature of the open fracture, as well as the extent of soft tissue injury and bony loss. The two basic treatment options for an open distal humeral fracture are an open reduction-internal fixation (ORIF) and an external fixation technique. In addition to the management of the soft tissues associated with open distal humerus fractures, treatment of the fracture itself follows similar principles used in a closed distal humerus fracture. Although many methods have been described for the ORIF of distal humerus fractures, the traditional and most popular approach utilizes one plate on the posterolateral column of the humerus and another plate on the medial column. This described plate orientation was based on a careful evaluation of their biomechanical stability, which was determined to be an orthogonal arrangement with the plates at 90° angles to each other. However, a recent study by O’Driscoll has cited that this orientation is unsubstantiated and incorrect, and that parallel placement of two plates in the sagittal plane is as strong or stronger than the 90° orientation. By linking the two plates through the bone via interdigitation and locking of the screws together
as they pass through the distal fragments from the medial and lateral plates placed in the sagittal plane, an architectural equivalent of an arch is created and, thus, offers the greatest biomechanical stability for comminuted distal humeral fractures.  

Recent literature has shown that external fixation is another effective option for the treatment of these injuries. In a retrospective study of 18 patients with open distal humerus fractures treated with immediate external fixation, Mostafavi and Tornetta found that, at an average follow-up time of 34 months, 12 patients (70%) had a functional elbow rating of good or excellent. One patient had a fair outcome and four patients were rated as poor. In this study, a unilateral external fixation frame, with half-pins proximal and distal to the fracture site, was used in all but one case for an average duration of 11 weeks. Some complications that arose from this type of external fixation were three malunions, eight pin-tract infections, and two late fractures after removal of the external fixator. Nevertheless, the investigators concluded that this type of external fixation helped achieve and maintain skeletal stability, while also allowing for sufficient treatment of any associated neurovascular or soft tissue injury.

In another study using external fixation, Chaudhary and colleagues utilized a bilateral uniplanar mini-external fixator construct for the treatment of open intercondylar distal humeral fractures. The mini-external fixator consisted of K-wires, connecting rods, and link joints of stainless steel blocks, with two offset holes to which the K-wires and connecting rods were clamped. In the study, the ultimate functional outcomes of eight patients with open intercondylar distal humerus fractures, who were treated with this special mini-external construct, were evaluated at a mean follow-up of 11.4 months. The device was removed after an average of 11 weeks, and it was found that all of the intercondylar fractures united with an average range of motion between 20° and 120°. Furthermore, of the eight cases treated with this external fixation technique, six of the patients achieved good to excellent results as determined by the Cassebaum’s functional rating system, in which a good result would be elbow flexion greater than 120° and an extension deficit less than 40°. Thus, the study concluded that this mini-external fixation technique represents a viable option in the management of open intercondylar fractures of the distal humerus, especially if the injury site has been contaminated, as that would render ORIF a suboptimal procedure.

Mahmut and coworkers found that using an Ilizarov circular external fixator may be another effective external fixation technique for the treatment of open, intra-articular distal humeral fractures. In their study, patients were first divided into two groups: those that presented to the hospital 6 to 8 hours after their open distal humerus fracture (7 patients) and those that presented at a later stage (12 patients). An Ilizarov circular external fixator was surgically attached to the elbow for all 19 patients in the study and remained on for a mean period of 4.6 months. After an average follow-up of 34.3 months, it was found that union was achieved in all 19 patients. The early treatment group had three patients with good results, three with moderate results, and only one with unsatisfactory results. In the late treatment group, five were good, four were moderate, and three were unsatisfactory. From these results and from the routine follow-ups with patients, the investigators were able to conclude that treatment of open distal humerus fractures with an Ilizarov external fixator helped to minimize soft tissue and vascular damage, allowed for early elbow movement, and, ultimately, permitted patients to regain their elbow function within a relatively short amount of time. In addition to these benefits, a separate study by Jupiter and Ring found that the Ilizarov construct helps to ensure the elimination of infection or colonization in contaminated fractures, which are often observed with open fractures of the distal humerus.

Aside from the actual fixation of the fracture, associated soft tissue injury and any bony loss should also be evaluated. If the soft tissue injury is significant, such that the wound cannot be fully closed after the fracture is operatively stabilized, closure may require a local skin or muscle (local flap) to cover the fracture with well-vascularized soft tissue. Considerable bone loss is another occurrence with open fractures of the distal humerus. Adequate restoration of the elbow anatomy following this bony defect can involve multiple procedures, including debridements, soft tissue coverage, and bone grafting. In a 2008 study, Kouvidis and associates employed a vascularized fibular osteocutaneous free graft to reconstruct a high-energy open fracture of the distal humerus. In addition to significant soft tissue and muscle damage, the entire medial column of the distal humerus was missing in the patient, and a 6-cm fibular osteocutaneous graft was used to reconstruct the bony defect. Postoperatively, there were no complications, and at 26-months follow-up, the bone graft was completely incorporated, with a solid fracture union. The patient had a stable and functional elbow with no pain or discomfort and had a Mayo Elbow Performance Score of 85. From this case study, the investigators were able to recommend that a vascularized osteocutaneous fibular graft could effectively restore significant bony defects that are often seen in open distal humeral fractures and ultimately enhance bone healing and functional recovery.

Complications
As with any surgical procedure, there is always a risk for infection after fixation of the fracture. The open nature of the fracture can predispose the patient to infection, as the fracture will most likely be contaminated even before surgical intervention. It is for this reason that emergent irrigation and debridement must be performed on all open fractures.

Other potential complications associated with these injuries include loss of range of motion. In addition, Mostafavi and Tornetta found that out of a total of 19 patients treated with a unilateral external fixator there were three malunions,
one delayed union, eight (44%) pin-tract infections, two pin-tract sequestrum formations, and two late fractures after removal of the external fixation. Non-unions, malunions, postruamtic arthrois, and heterotopic bone formation are also complications that may be encountered.5,6

Ulnar nerve neuropathy is a less common complication that can be seen in open fractures of the distal humerus. Care should be taken to protect the ulnar nerve from intra-operative damage by elevating the nerve from the cubital tunnel, proximally, to the level of the medial intermuscular septum and, distally, past its entrance between the two heads of the flexor carpi ulnaris. The role of routine ulnar nerve transposition in distal humerus fractures was examined by Wang and colleagues, who recommended routine ulnar nerve transposition after operative fixation.11 However, the study lacked a control comparison, and to date there are no good clinical studies that have examined the role of routine transposition.

Outcomes
Given the different degrees of open distal humerus fractures and the variety of treatment options available, it is difficult to interpret any reported outcomes after treatment of the injury. No long-term or large-scale studies have been conducted to determine the functional outcomes specifically from open fractures of the distal humerus. However, of the studies mentioned regarding external fixation for treatment, the percentage of reported good or excellent outcomes ranged from 70% to 78%.5-7 Average range of motion was found to be 20° to 120°.6 Data on outcomes from ORIF performed on open distal humerus fractures is currently unavailable.

Although both ORIF and external fixation have been used for the management of open distal humerus fractures, there is still a paucity of literature comparing the functional outcomes of the two techniques. Some research has concluded that the contamination associated with all open fractures may preclude an ORIF technique, due to its high risk for infection.12 Furthermore, in a study on intra-articular distal humerus fractures (both open and closed), Kundel and colleagues13 observed that patients with open fractures had less favorable results when treated with ORIF. This study, however, did not directly compare the outcomes of ORIF and external fixation in open distal humerus fractures. Thus, there is still no consensus on the optimum treatment technique for the management of these open fractures.

Results
Tejwani and coworkers’ retrospective reviewed 32 (14 open and 18 closed) Type C distal humerus fractures, treated operatively from January 2005 to December 2008, with an average follow-up of 54.1 weeks (range, 26.6 to 159.7 weeks). The average age of patients was 45.8 years in open and 67.0 years in closed fractures, with similar gender distributions. All open fractures had initial debridement and external-fixation was placed in 12 cases. Definitive fixation was carried out in all 32 fractures using dual plate fixation. Time to union was 24.74 weeks for open fractures versus 17.9 weeks for closed, with final follow-up ROM being 79° and 110°, respectively. Two nonunions in the open cohort required an additional 20 weeks after revision for healing. Bridging heterotopic ossification was seen only in two of 14 open fractures. Nerve injury was seen in nine cases (eight ulnar and one radial), six of which were associated with open fractures. One open fracture patient developed a postoperative infection. They found that, as compared to closed fractures, open distal humerus fractures were more prone to loss of range of motion, prolonged time to union, nerve injury, and more heterotopic ossification requiring further surgery.14

Conclusion
Open fractures of the distal humerus are difficult injuries to treat. They have been found to predominantly affect younger males involved in high-energy injuries, as well as older, osteoporotic females involved in lower energy situations. The emergent and complex nature of these open fractures can make it a challenge to treat. Both ORIF and external fixation have been used with success to stabilize the skeletal injury. However, a thorough analysis of the functional outcomes from these surgical techniques has still not been undertaken. Therefore, it is clear that ongoing research is necessary to promote future improvements in treatment and rehabilitation of open distal humerus fractures.

Disclosure Statement
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