Abstract

Humeral fractures account for approximately 5% of all fractures. They predominantly result from either an external force or a fall on an outstretched hand (FOOSH). Many forces contribute to these injury resulting in either 2, 3, or 4 part, proximal or distal, fractures. Open reduction internal fixation (ORIF) of a humeral fracture is among the most common surgical approach used for this repair. The technique used to repair the fracture depends on the type of fracture that has occurred and the approach preference of the physician. The deltopectoral approach to fix a 3 or 4 part proximal humeral fracture is the most likely ORIF to be seen in clinical practice. A 12 week physical therapy regimen is required following the surgery. This regimen is split into phases that include set precautions, contraindications, and protocol to achieve goals for that phase. This is exemplified via a case study on a 30 year old male with an ORIF of a 3 part proximal humeral fracture.

Introduction

Humeral fractures most often occur proximally, near the surgical neck or on the head of the humerus. Humeral fractures may be treated using a number of methods ranging from humeral immobilization to a hemiarthroplasty. One technique that has gained popularity in recent years is the ORIF surgery using locking plate technology. This
technique is favored due to its fast recovery time and reduced likelihood of complications in comparison to more traditional techniques. This technique is especially favored in cases where a part of the fractured bone has been displaced as is often the case in three and four-part fractures.

**Common Mechanism of Injury**

The most common mechanisms of injury in young healthy adults includes direct contact and falling on an outstretched hand. These fractures often occur due to participation in contact sports or motor vehicle accidents. In these cases a comminuted or transverse fracture to the surgical neck or the anatomical neck are most common. In older adults, fractures most often occur as a result of a fall in those with a preceding osteoporotic condition. In this case, a fall on an outstretched hand with the arm and forearm maximally internally rotated, causes the compressive force to travel from the radius to the ulna and up the humerus. This action often forces the humerus into the glenoid and can result in an impingement of the greater tuberosity under the acromion. If the force is strong enough, the force can cause the greater tuberosity to fracture and/or displace from the rest of the proximal humerus.

In both of the aforementioned circumstances, surgery may be used to reduce the fractured sites, if they were displaced, as well as provide a stable, fixated surface that the bone can heal around.

**Indications for Surgery:**

Humeral fractures are primarily treated using conservative measures unless bone fragments are found to be displaced. Even with displacement, a surgeon may choose not perform the surgery based on the functional status of the patient, the
presence of comorbidities or the number of displaced bone fragments detected\textsuperscript{1}.

Additional factors that must be weighed include: the patient’s age, smoking habits, degree of communication, functional ability and severity of osteoporosis\textsuperscript{3}.

**Classification of Fractures:**

When a patient presents with a proximal humeral fracture, the surgeon must determine what the best course of treatment should be based on the aforementioned considerations. While every injury will present differently, a classification scheme of classic fracture patterns, called the Neer classification is often used to categorize humeral fractures based on the location of the fracture, the number of bone fragments, and the displacement of the fracture.

Under this classification, one part fractures involve one or more fracture lines with minimal displacement of the surgical neck, greater tubercle, or lesser tubercle. This fracture is often treated conservatively.

Two part fractures involve two fracture sites and may, additionally, include damage to the the anatomical neck. They may range from minimally displaced to severely-displaced. Still, most minimally displaced two part fractures are treated nonoperatively; although there is a risk of a nonunion with this treatment in cases where the bone fails to heal properly. This may result in pain and functional deficits months to years after the initial injury. In this case, the patient may need surgery\textsuperscript{1}.

In the case of three or four-part fractures, surgical intervention is almost always indicated. As the number of fracture sites on the humerus increases, the stability of the joint decreases. Due to the force of the supraspinatus and infraspinatus on the greater
tubercle, as well as the subscapularis on the less tubercle, displacement is more likely to occur, causing pain and decreased functional ability\(^1\).

**Surgical Intervention:**

One of the more common approaches for this surgery is the deltopectoral approach. This approach is favored for protecting the axillary nerve; however, it is disliked for its increased risk of cutting the posterior humeral circumflex artery and for its limited access to the posterior humerus, which makes it harder to insert a plate. Once an approach is chosen, a stainless steel or titanium plate and screws are often used to stabilize the humeral bone and fractured segments\(^5\). There are two options for plating: traditional and locked plating methods. In comparison to traditional plating, locked plating, decreases the amount of contact pressure between the plate and the periosteum thus allow increased blood flow to the humeral head\(^9\). It is also lower profile and requires less bone loss which is good for maintaining muscle alignment and bone strength\(^5\).

In proximal 3 part fractures, several sutures are often used to unite the bones back together. First, a greater tuberosity suture is pulled medially and a lesser tuberosity suture is pulled laterally before a cancellous allograft is placed into any remaining spaces so that the bone assumes a normal contour again. Next, a reduction suture is placed between the tuberosities using a figure of 8 shape. Finally, a suture is placed from the rotator cuff tendons at the bone-tendon junction and then through a drill hole at the lesser tuberosity. Following the placement of sutures, a proximal humeral locking plate is used to unite the head and tuberosity fragments with the shaft. It is important that when the plate is inserted, the humeral head is pointing directly into the
glenoid and the arm is held in neutral rotation. If this does not occur, then the bone may not be aligned properly and complications can take place. After the plate is inserted, an initial reduction screw is used to adhere the plate to the bone, followed by the remaining screws as indicated by the physician. Then, an additional sutures are used to adhere the rotator cuff muscles to the plate through small holes left in the plate.

**Biomechanical Considerations**

There are several biomechanical properties that may affect a person’s injury before the surgery is performed. One such property, is the pull of the rotator cuff and the pectoralis muscles on the fractured bone segments. Often, in 3 part surgical neck fractures, the muscles inserting onto the greater tubercle pull the superior fragments of the fracture into an externally rotated position while the internal rotators adduct the lower fragments. If this issue is not addressed, the aforementioned muscles may pull a displaced bone farther out of place. In this case, a patient may experience an adaptive shortening of the humerus due to misalignment of the displaced fracture. In addition, the length of the muscles may also change their alignment or length to fit the newly shaped bone. These changes may lead to changes in muscle power, function and line of force.

There are also several mechanical factors that must be taken into account before the surgery is performed such as, plate type. Research suggests that the most common reasons for plate failure include: mechanical bending stress on the plate, disunion from the bone due to bone weakness or uneven stresses on the bone. Therefore, the surgeon must balance the necessity of fixation, flexibility and strength elements to produce the greatest outcome. For instance, longer, less flexible plates with larger
screws are generally less affected by external forces due to their strength but are also not as good at distributing experienced forces.

In addition, the placement of the plate has a great affect on the biomechanics of the arm. Generally, it is recommended that a locking plate be positioned 10-15mm distal to the greater tuberosity in the subchondral bone to reduce the chance of impingement of the supraspinatus tendon and to produce the greatest normal range of motion. If the plate were to be placed more superficially or proximally, the patient may experience additional discomfort post-surgery.

Furthermore, screw placement and type can have a large effect on the biomechanics of the surgery. This is one of the main reasons that locked plate technology is preferred over traditional plate technology. Traditional plates use screws that move and therefore rely on a frictional force between the plate and the bone. They act as an internal fixator. Locking plates, in contrast, lock into place and do not require the bone to maintain fixation and act as internal-external fixators. The fixed placement of the screws are designed to better disperse harsh shear forces experienced by the surgical as compressive forces to reduce the chance of fixation to the bone.

Finally, there are some post-surgical considerations that one must take into account with regard to biomechanics. Following the surgery, patients are normally placed in a sling, which also provides stress relief to the bone. This may be great for the healing of the tissues that are affected by the surgery; however, the weakening of the bone and muscles as a result of this sling must be addressed. For example, if a patient is kept in a sling for too long, they may exhibit much weaker bones, and thus less fixation than someone who was allowed to put stress through the bone much earlier.
References


11. Email Communication with James Connelly, PT in October, 2014.
