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Proximal humerus fractures: Treatment controversies

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Abstract The treatment of proximal humerus fractures is challenging, and significant controversy exists even regarding which patients are indicated for surgical treatment. When surgery is indicated, open reduction and internal fixation is the most common type of treatment. Arthroplasty is reserved for unreconstructible fractures. Hemiarthroplasty may not provide good, reliable function but may be the best option in younger or middle-aged patients when fracture fixation is not feasible. While several studies reported no benefit of surgical treatment in elderly patients, more recent literature showed better outcomes with reverse total shoulder arthroplasty.

Keywords: proximal humerus fractures, fixation, arthroplasty, hemiarthroplasty, reverse total shoulder arthroplasty

Although a very common injury and the third most common fragility fracture, there is no consensus regarding the best treatment of proximal humerus fractures (PHFs), especially in the elderly. The benefits of operative treatment have been questioned, and the role of surgery to repair proximal humeral fractures has been a topic of significant controversy. Arthroplasty has been traditionally indicated for unreconstructible fractures; however, the type of arthroplasty (hemiarthroplasty vs. reverse total shoulder arthroplasty) is debatable in middle-aged patients. In the past decade, there was a trend toward reverse arthroplasty as a primary method of treatment in the elderly.

1. Nonsurgical versus Surgical Treatment

PHFs are among the most common fractures. Among hospitalized patients, the reported incidence in all age groups is 45–90/100,000 persons/year worldwide, a number that increases by a factor of 1.7 when outpatient cases are included.[1,2] The incidence increases with age, affecting older women 4 times more than men, up to 503/100,000 persons/year in women older than 65.[1] There is a wide spectrum of fracture types of PHF, generally classified according to the four-segment classification system. Depending on the number of fracture lines, they are classified as 2-part (one fracture line), 3-part (2 fracture lines), or 4-part (3 fracture lines), resulting in as many as 12 to even 16 different types when including displacement and glenohumeral dislocation.[3,4]

The challenge in this heterogeneous group of fractures and patients is to determine which treatment is appropriate for which fracture type and for which patient. There are several treatment options, ranging from nonsurgical treatment (NST) to surgical treatment (ST), which may include various methods of fracture fixation or arthroplasty.

Nonsurgical management remains by far the most common treatment, with an incidence of 85%–90% that remains the same over the years. The other 10%–15% of fractures are treated surgically, but there is wide geographic variation in the proportion of fractures treated surgically, ranging from 2% to 33% even within one country.[5,6] In addition, the type of ST is evolving, with a trend away from osteosynthesis toward reverse shoulder arthroplasty (RSA).[7] Regardless of the treatment modality, high levels of disability, functional limitations, and reduced quality of life are still commonly reported at midterm and long-term follow-up.[8,9]

Randomized controlled trials (RCTs) comparing NST with ST may help us decide which treatment to choose for a given patient. There are 11 RCTs comparing NST with ST published between 1984 and 2023.[9–20] One RCT was published twice with different follow-up periods.[13,14] These RCTs study different populations with different inclusion and exclusion criteria, which must be considered when applying their conclusions to a specific case.

Some earlier RCTs report slightly better outcomes with ST,[9–11] but more recent RCTs conclude that ST is not superior to NST and has a significantly higher complication rate.[17,20] Regarding the type of fracture treatment, 4 of them compare NST with arthroplasty (3 with hemiarthroplasty[10,15,16] and one with RSA[19]), 5 of them compare NST with osteosynthesis (one with external fixator,[11] one with tension band,[12] and 3 with locking plate[9,13,14,18]), and 2 of them compare NST with a mixture of

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osteosynthesis and arthroplasty.[17,20] Regarding fracture type, 5 RCTs include one fracture type (one includes 2-part surgical neck fracture,[18] one 3-part PHFs,[9] and three 4-part PHFs[10,15,16]), 4 RCTs include 3- and 4-part PHFs,[12–14,19,20] and 2 RCTs include 2-, 3-, and 4-part PHFs.[11,17]

The percentage of displacement at the level of the surgical neck is mentioned as an exclusion criterion for nonsurgical management in 5 studies, all comparing NST with osteosynthesis. However, studies are not consistent in what they exclude from consideration for NST. In one study, displacement >50% was excluded[13,14]; in another, >70% was not allowed[12]; in 2 studies, only complete dislocation was excluded[9,18]; and in one study, sufficient displacement for the surgeon to recommend surgery was adequate for exclusion.[17] The age groups allowed also differ, with 4 studies including all age groups,[10–12,17] 2 studies with age older than 55 years,[9–15] 3 studies with age older than 60 years,[13,14,18,20] one study with age older than 65 years,[16] and one study with age older than 80 years.[19]

In a systematic Cochrane review of 47 comparative trials to assess the effects of treatment and rehabilitation interventions for proximal humeral fractures in adults, most trials were found to be at high risk of bias, mainly due to lack of blinding. There was high- or moderate-confidence evidence that surgery does not result in a better outcome than nonoperative treatment at 1 and 2 years. It was, however, concluded that there is insufficient evidence to inform the choice between different nonoperative, surgical, and rehabilitation interventions for these fractures.[21]

In addition to the RCTs, there are 11 meta-analyses of RCTs comparing NST with ST published between 2013 and 2022.[21–31] They analyze between 3 and 10 of the abovementioned RCTs. According to Sandau who analyzed the methodological quality of 21 systematic reviews consisting of 19 pairwise meta-analyses and 2 network meta-analyses, the quality was so critically low that it was not possible to assess the relationship between methodological quality and the reported conclusions.[32]

We can conclude that an evidence-based treatment choice for displaced PHFs lacks strong support from the literature, but there are indications that ST is not superior to NST especially in the elderly. Future focus should be on subgroup analysis in well-designed trials and on the introduction of new surgical principles to reduce complications in ST of PHFs.[33]

2. Hemiarthroplasty versus Total Shoulder Arthroplasty

PHFs are the third most common fragility fractures, and the incidence is increasing along with the aging population. The goal of treatment is return to previous functional level safely and effectively. While there is a consensus regarding the goals of management, the type of treatment to be recommended is very controversial. Surgery is indicated when there is significant displacement and when the fracture pattern is unstable, since nonoperative treatment of unstable displaced fractures will result in malunion or nonunion, which in turn is associated with loss of motion, pain, and weakness. In patients who are completely dependent for self-care or with significant cognitive impairment, the appropriate treatment is nonoperative. When indicated, surgical options are fixation or arthroplasty. While several techniques of fixation are described, open reduction and internal fixation is the most common method. Restoration of anatomic relationship of humeral head, tuberosities, and humeral shaft is critical. Arthroplasty should be reserved when one cannot obtain stable fixation to start early progressive gentle range of motion.

Indications of arthroplasty are (1) comminuted 3- or 4-part fractures with poor bone quality, (2) significantly displaced anatomic neck fractures, (3) head split, and (4) fracture dislocations (excluding 2-part greater tuberosity fracture dislocations). Although these fracture pattern–specific indications are commonly accepted, in younger and middle-aged patients, we recommend considering fixation; although the failure rate may be high, saving the humeral head is worth trying. Fortunately, the fracture patterns that require arthroplasty occur mostly in older patients. While chronologic age is not always correlated with physiologic age, we consider arthroplasty in patients older than 75 years or in patients older than 65 years with severe medical comorbidities.

Arthroplasty options are hemiarthroplasty and reverse total shoulder arthroplasty. While hemiarthroplasty provides satisfactory long-term pain relief, range of motion and function are unpredictable.[34–39] The poor results after hemiarthroplasty are usually associated with failure of healing of tuberosities and impaired function of the rotator cuff. Therefore, repairable tuberosities are an absolute prerequisite for a functional hemiarthroplasty. Some RCTs comparing nonoperative treatment with hemiarthroplasty in 4-part fractures showed improved outcomes[9] with hemiarthroplasty, but other studies showed no difference.[16] Hemiarthroplasty has limited indications but must be considered as part of the treatment algorithm in select group of patients. In patients aged 50 to 65 years, we perform hemiarthroplasty when fracture is not fixable to start early progressive range of motion or if they have significant comorbidities associated with poor bone quality and low healing potential.

When arthroplasty is indicated for a PHF, reverse total shoulder arthroplasty has become increasingly the primary choice in the past decade since the outcomes are better and predictable compared with hemiarthroplasty.[40,41] More studies report good outcomes with reverse total shoulder arthroplasty.[42] Survival of reverse total shoulder arthroplasty in the long term is a disadvantage when implanted in younger patients. We recommend reverse total shoulder arthroplasty in patients older than 75 years or in patients older than 65 years with severe comorbidities or when tuberosities are not repairable.

In summary, arthroplasty should be considered when one cannot obtain stable fixation to start early progressive gentle range of motion. While the patients are usually older than 75 years or older than 65 years with severe medical comorbidities, arthroplasty may be indicated in younger patients with unfixable fracture patterns. Reverse total shoulder arthroplasty provides better and predictable results and is mostly the choice when arthroplasty is necessary. Hemiarthroplasty has limited indications but must be considered as part of the treatment algorithm in select group of patients.

3. Reverse Total Shoulder Arthroplasty for PHFs: When and How

Despite advances in locking plate technology, complex fractures of the proximal humerus remain challenging and poor clinical results after fixation are common, particularly in the elderly. In the past, hemiarthroplasty (HA) has been the gold standard treatment for unreconstructible fractures of the proximal humerus, but a high rate of poor functional results is reported with associated tuberosity nonunion or resorption.[43] Reverse total shoulder arthroplasty (RTSA) has become the preferred treatment method for these fractures due primarily to the fact that it is not as dependent on tuberosity healing and rotator cuff

function.[44] There is evidence that healing of the tuberosities can improve the overall function following RTSA (especially rotation), but failing to do so does not usually result in the devastating functional loss of flexion and rotation seen when this complication occurs in the setting of hemiarthroplasty.[45–48]

RTSA for fractures is reserved for older patients (>70 years of age) with more complex injury patterns, including 3- and 4-part fractures. Fracture dislocations are also a relative indication if the viability of the humeral head is in question due to lack of a medial hinge, short calcar extension, or severe displacement. RTSA is indicated for iatrogenic fracture dislocations, in which the humeral head is sheared off during attempts at reduction. Individuals with preinjury significant rotator cuff dysfunction or pathology (either by clinical history or on imaging) are good candidates for RTSA. Finally, RTSA remains an effective option for failed primary fracture surgery for proximal humeral fractures.[49]

The performance of RTSA is associated with a significant learning curve. A study of 62 consecutive RTSA procedures performed by a single surgeon showed that operative time stabilized and technical issues related to implant positioning improved after 18 cases or so.[50,51] It is important for the surgeon to establish proficiency with RTSA through senior mentorship, careful case selection, cadaveric courses, and literature review before adding this procedure to their armamentarium.[50]

Our preferred approach is through the deltopectoral interval with the patient in the semisitting or beach chair position. This allows excellent exposure of the glenoid and proximal humeral fracture fragments and does not compromise the deltoid (critical for RTSA function). The incision begins at the tip of coracoid and extends distally approximately 7–10 cm depending on the size of the patient. The cephalic vein is usually taken medially, and the deltoid is retracted laterally. Complete muscle relaxation augments the procedure. The long head of biceps is identified and tenodesed at the superior margin of the pectoralis major. The lesser and greater tuberosities are identified, cleaned of debris, and mobilized; then, 2 retraction sutures are placed each at the edge of the cuff attachments. The humeral head fragment is removed, and the glenoid is exposed with retractors anteriorly and posteriorly. The anterior capsule is released and then excised. The labrum is excised circumferentially, and the inferior margin of the glenoid is carefully identified to aid with placement of the glenoid baseplate. It is important to avoid injury to the axillary nerve. The cartilage of the glenoid is then removed, and the size, shape, and version of the glenoid are assessed. In contrast to most arthritic cases, the glenoid in fracture cases usually has minimal deformity. Using the guide from the system chosen, a pin is placed into the glenoid, which dictates the anteroposterior position, superoinferior position, inclination, and version of the glenoid component. To avoid notching, the lower border of the baseplate should be aligned with the inferior margin of the glenoid and should be angled slightly inferiorly. The glenoid is then prepared and the appropriate baseplate inserted.

The humerus shaft is exposed with adduction, extension, and external rotation of the arm, and the humeral canal is identified. In cases of metaphyseal comminution, the positioning of the height of the humeral stem can be challenging and the superior border of the pectoralis major tendon can be a used as a landmark (5.6 cm inferior to the top of the humeral head).[52] The canal is then prepared until the selected trial has rotational and axial stability. An uncemented humeral stem is preferred, but a cemented stem may be necessary especially in the setting of metaphyseal comminution to achieve longitudinal, axial, and rotational stability.

A trial reduction is then performed: both clinical and radiographic assessments are helpful. This helps to determine component size, height, and version. It should be remembered that stability will improve with both the return of muscle tone and repair of the tuberosities. The permanent glenosphere, tray (if applicable), and liner are then impacted into place. A variety of techniques have been described to repair the tuberosities: in general, sutures should pass through the tuberosities, through the shaft, and around or through the prosthetic stem. A biomechanical study demonstrated that a stem-based tuberosity repair technique provided higher ultimate load to failure with less displacement than a nonstem-based technique.[53] Two technical tricks that may improve fixation include "debulking" of the metaphyseal bone of the tuberosities to improve apposition to the stem and resection of the superior part of the residual rotator cuff to decrease tension on the tuberosities.

Multiple studies of RTSA for proximal humeral fractures have demonstrated overall good results with Constant scores between 44 and 68, active forward flexion ranging from 90 degrees to 125 degrees, abduction from 97 degrees to 113 degrees, and external rotation of approximately 18 degrees to 25 degrees.[54] In a systematic review, a mean Constant score of 56, active forward elevation of 122 degrees, abduction of 97 degrees, and external rotation of 18 degrees were reported.[55] Complication rates including infection, dislocation, and tuberosity nonunion are higher than for RTSA for arthritic conditions, but still at an acceptably low rate.

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