Fix or Replace?

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12.1 Introduction

Proximal humeral fractures account for about 10% of all fractures [1, 2], and the incidence is increasing [3]. The majority of minimally displaced fractures are successfully treated nonoperatively [4], but the optimal management of displaced or complex fracture remains controversial. Devascularization of the humeral head, associated injury to the rotator cuff, and the high prevalence of osteoporosis in elderly patients make the decision-making and the treatment very challenging. Current evidences are not able to give a useful guideline among prosthetic replacements, intramedullary nails, fixed angle locked plates, and conservative methods [5, 6]. Different classifications, based on fragment number and displacement, have been proposed for these difficult fractures [7–10]. This topic has been widely described in a previous chapter (2f—Borroni). However, no system can predict the ideal treatment option, and all ones have poor intra-and interobserver variability [11, 12]. Understanding the vascular supply of the humeral head is mandatory when planning surgical treatment. Arthroplasty surgery should be more useful in a fracture pattern in which the humeral head is at risk of avascular necrosis, while internal fixation should be better in a fracture pattern, whereby the risk of devascularization is low. The principal blood supply to the head has been shown to originate from the anterior humeral circumflex artery through the arcuate branch [13] with a helpful role by the posterior humeral circumflex [12]. Different fracture patterns have been associated with a higher risk of humeral head necrosis: medial metaphyseal head extension more than 8 millimeters, disruption of the posteromedial hinge, and any fracture disrupting the anatomical humeral head [12]. The presence of any of these features should prompt the clinician to consider arthroplasty surgery as a more reliable treatment option.

12.2 Non-operative Treatment

The most part of patients with proximal humeral fractures can be managed nonoperatively [14] with a high union rate [15, 16]. The treatment would involve 2 or 3 weeks of immobilization followed by progressive mobility under the guidance of a physiotherapist. Retrospective studies have reported high rates of patients with good or excellent outcome [4, 14], with an average of 111–120° of forward flexion and 100–106° of

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abduction [15, 16]. The decision to proceed toward a surgical intervention is based on four factors: age, bone quality, fracture pattern, and timing of surgery [17]. The combination of a clinical history, examination findings, and radiographic investigations plays a critical role in decision-making process. Main elements of the history are patient age, date of injury, hand dominance, preinjury functional level, comorbidities, cognition, social status, and compliance to rehabilitation. Clinical examination should confirm the integrity of the axillary nerve, brachial plexus, and axillary artery.

12.3 Operative Treatment

Preoperative plain radiographs should include the complete shoulder series: anterior-posterior view of the glenohumeral joint and axillary and lateral views. Imaging studies should demonstrate the congruity of the glenohumeral joint, the number of fracture fragments, the degree of fracture displacement, and the presence of risk factors for a future humeral head necrosis. Computed tomography (CT) scanning with three-dimensional reconstructions is mandatory when planning internal fixation or prosthesis implant [12].

12.4 Plate Fixation

Surgical fixation should preserve articular surface congruency, alignment, and vascularity to the humeral head. It is mandatory to achieve an accurate reduction and to restore the medial calcar support [18, 19]. Screws should engage into the subchondral bone where the bone quality is greatest and should include inferior-medial screws [20]. The plate should be positioned at least 5 mm distal to the greater tuberosity to avoid impingement during abduction [21]. Reduction and fixation of the tuberosities can be done using screws but more commonly with sutures onto the plate. Intraoperative evaluation of the passive movement is necessary to check stability and to program the correct postoperative rehabilitation. Passive rehabilitation should start after few days from surgery. The surgical approach is performed through a deltopectoral or lateral deltoid splitting approach depending upon surgeon preference. The dissection may increase the risk of necrosis of the humeral head [22], and the plate use in three- and four-part fractures is uncertain especially in elderly patients. In young patients, where three- or four-part fractures can be reduced and the bone quality is adequate, a plate fixation can be performed. In elderly patients, when the bone is of poor quality, the articular surface damaged, and the blood supply compromised, then a prosthesis implant should be considered [23]. If the patient is under 60 years of age, open reduction and internal fixation should be considered even for complex cases. In these cases, a perfect tuberosity reduction should be searched, because, even if avascular necrosis occurs, the anatomic union of tuberosities will be advantageous for future arthroplasty surgery. In these cases, if plate fixation fails, salvage prosthesis implant is possible, but reported outcomes are poorer than in cases of primary hemiarthroplasty [24, 25].

12.5 Intramedullary Nailing

Usually intramedullary nailing has been used to treat humeral shaft fractures. To give more stability to the proximal part, nails with polyaxial screws were developed. This gives a valid option for the management of proximal humeral fractures. Two-part fractures are more eligible to be treated with intramedullary nails with respect to three- or four-part fractures. The advantage of the intramedullary devices is that less soft tissue disruption is required at the fracture site lessening the risk of humeral head necrosis. The entry point violates the rotator cuff often leading to residual shoulder pain [26, 27]. The complication rate is high with 10% developing impingement, 31% requiring removal of metal work, 12% developing AVN, and 4% requiring early revision [28, 29].

12.6 Hemiarthroplasty

The use of hemiarthroplasty for proximal humeral fractures was first described by Neer with 98% of satisfactory outcomes [30, 31]. At the present time, its ability to restore normal shoulder kinematics and function is still debated [32]. Indications for hemiarthroplasty are fracture dislocations and humeral head splitting fractures [33]. Hemiarthroplasty implant, in the management of these complex fractures, is difficult and still controversial depending on fracture features and patient's compliances. Elderly patients with low functional requirements, high comorbidities, and poor bone quality are more likely to benefit from hemiarthroplasty, but in these cases reverse shoulder prosthesis seems to be more effective in outcomes. Comminuted fractures, severely displaced, with features associated with avascular necrosis would be candidates to hemiarthroplasty. Tuberosity malunion or resorption returns to impaired functional outcome. A proper rehabilitation program is needed for achieving good outcomes [34]. Usually this will involve 4 weeks of shoulder support with pendulum and passive movement with active movement starting, in a pool, from 6 weeks. Complications as tuberosity non-union (11%), heterotopic ossification (9%), proximal migration of the prosthesis (6.8%), infection (2%), and nerve injury can affect the outcomes [32]. In addition, the glenoid can suffer for the pressure of the humeral head implant that can lead to glenoid wear causing pain and future revision surgery [35].

12.7 Reverse Arthroplasty

Reverse shoulder arthroplasty was dedicated and used for cuff tear arthropathy (CTA). The reverse arthroplasty medializes and lowers the center of rotation of the glenohumeral joint. This increases the torque force of the deltoid, by increasing tension and recruiting more muscle fibers, and allows greater shoulder elevation independent of the rotator cuff [36, 37]. The use of reverse shoulder athroplasty (RSA) was enlarged to treat complex proximal humerus fractures to restore function not taking into account the tuberosity healing which is extremely difficult in elderly patients with poor-quality tuberosities and with comminution of the bone fragment. It is mandatory to evaluate the right function of the axillary nerve because the denervation of the deltoid would result in a not recovered function. The use of RSA is recommended for patients over 75 years with complex fractures of the proximal humerus. This device usually provides similar pain relief to hemiarthroplasty and a better function in most of the cases even with tuberosity resorption in this elderly group [37]. Despite the good outcomes, there is a high complication rate with nerve palsy (11.6%), reflex sympathetic dystrophy (7%), prosthesis dislocation (2.3%), resorption and displacement of tuberosities (44.2%), and scapular notching (23.2%) [38]. Long-term follow-up showed radiographic evidence of glenoid loosening [39].

12.8 Discussion

The most part of proximal humeral fractures are minimally displaced and should be successfully managed conservatively. However, the treatment of displaced fractures remains controversial [5, 6], and it is still unclear when surgical intervention is necessary and with which surgical technique. The lack of adequately powered randomized controlled trials (RCT) precludes definitive conclusions over the optimal treatments.

Network meta-analysis (NMA) is a comparatively new evidence-based technique in medical disciplines which compares the relative benefits associated with multiple interventions and obtains hierarchies of these interventions for various treatment options. Chen et al. [40] evaluated the effectiveness and safety of open reduction and internal fixation (ORIF), hemiarthroplasty (HA), reverse shoulder arthroplasty (RSA), intramedullary nailing (IN), and nonoperative treatment (NOT) of displaced proximal humeral

fractures in adults. RSA resulted in a lower incidence of additional surgery than ORIF and IN. The rank of treatments in terms of high constant score was RSA, ORIF, IN, NOT, and HA. The rank for reduction in total incidence of complications was RSA, NOT, HA, IN, and ORIF. For lowering the risk of additional surgery, the rank was RSA, NOT, HA, IN, and ORIF. RSA had the highest probability for improving functional outcome and reduction in the total incidence of complications and requiring additional surgery among the five interventions for treating adults with displaced proximal humeral fracture.

One RCT comparing hemiarthroplasty and locking plate fixation for four-part fractures has reported no significant difference in functional outcomes between the groups [41]. Systematic reviews have reported comparable functional results with reverse arthroplasty and hemiarthroplasty [37, 42]. The reverse arthroplasty is receiving increasing support due to its ability to restore function independent of tuberosity union. The problem of treatment of complex three- and four-part proximal humeral fractures with hemiarthroplasty in elderly patients has yielded mixed clinical results. Reverse shoulder arthroplasty has emerged as a treatment option for comminuted proximal humeral fractures for these patients. Reverse shoulder arthroplasty resulted in better clinical outcomes and a similar complication rate compared with hemiarthroplasty for the treatment of comminuted proximal humeral fractures in the elderly. The clinical outcomes and range of motion values of these elderly patients who were treated with a hemiarthroplasty for an acute comminuted proximal humeral fracture exhibited a bimodal distribution of good outcomes if tuberosity healing occurred or poor outcomes if their tuberosities underwent resorption. In comparison, the patients who underwent reverse shoulder arthroplasty had more consistent and superior results irrespective of tuberosity healing [43]. In a nationwide registry-based cohort study comparing patients undergoing primary RSA with patients undergoing primary hemiarthroplasty for acute proximal humeral fractures, RSA appeared to produce functionally superior results to hemiarthroplasty at 5 years postoperatively [44]. Theoretical advantages include relative independence from relying on a functioning supraspinatus for active elevation, potential rapid recovery, and reduced need for postoperative rehabilitation [45, 46]. Studies to date have demonstrated that RTSA provides predictable pain relief with reliable functional gains, especially with tuberosity healing. However, complication rates up to 50–68% have been

reported, including hematoma formation, scapular notching, loosening of the glenoid component, instability, and component dissociation [37, 38, 47, 48]. RTSA appears to provide range of motion superior to that of HA and ORIF. RTSA predictably restored active elevation over horizontal plane in all patients within 4 months. RTSA realized even significant cost savings compared with ORIF and HA [45].

12.9 Conclusion

Summarizing, the elderly patients treated with reverse shoulder arthroplasty had better clinical outcomes, better forward elevation, higher tuberosity healing rates, and a lower rate of revision surgery compared with those who had hemiarthroplasty and open reduction and internal fixation for the treatment of a comminuted proximal humeral fracture.

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