RESEARCH ARTICLE

Corrective Osteotomy for Intra-Articular Distal Humerus Malunion

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Received: 25 January 2015 *Accepted: 8 September 2015*

Abstract

Background: An intra-articular distal humerus malunion can be disabling. To improve function, reduce pain and/or prevent further secondary osteoarthritis an intra-articular corrective osteotomy can be considered. Herein we present the indications, practical guidelines for pre- operative planning and surgical technique. Subsequently, we provide long-term results in a small series.

Methods: We included six consecutive patients operated for intra-articular distal humerus malunion. Mean follow-up was 88 months. At lastest follow up elbow function was assessed according to standardized questionnaires and classification systems.

Results: All six patients healed their osteotomies. Three patients had a postoperative complication which were treated succesfully. Range of motion improved significantly and all patients were satisfied with the outcome. The elbow performance scores were good to excellent in all. Correlation analyses showed that age and level of osteoarthritis are very strong predictors for the long-term elbow function and quality of life.

Conclusion: An intra-articular corrective osteotomy for a malunited distal humerus fracture is a worthwhile procedure. Based on our results it should particularly be considered in young patients with minimal osteoarthritis and moderate to severe functional disability and/or pain.

Keywords: Distal humerus fracture, Distal humerus malunion, Intra-articular corrective osteotomy, Long-term follow-up

Introduction

Distal humerus fractures are uncommon, accounting for only 2% of all fractures.

Open reduction and internal fixation to restore anatomy and allow early motion is the preferred treatment of distal humerus fractures (1). However, the often complex articular fracture anatomy, comminution and limited cancellous bone support can make operative fixation challenging (2). Malunion is one of the most frequent complications (30%) of distal humerus fractures most often treated conservatively (3).

An intra-articular distal humerus malunion with a joint incongruity is disabling with symptoms including stiffness, pain, posterolateral rotatory instability, ulnar nerve palsy, weakness, deformity and post-traumatic osteoarthritis. There is also an increased risk of lateral condylar fractures due to the malunion (4). An intra-articular corrective osteotomy can be considered to improve function by increasing range of motion, decrease pain and/or prevent further secondary osteoarthritis (5). Intra-articular reconstructions are technically demanding and best reserved for early cases of malunion with little or no secondary post-traumatic osteoarthritis. However, there is a paucity of literature regarding the surgical technique and functional outcome of this challenging procedure (5, 6).

Based on our grouped experience, we herein present

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Table 1. Summary of patient characteristics

Case number	Gender	Side	Initial treatment	Age at time of osteotomy	Follow up (Months)	Type of Malunion	Approach	Bone graft
1	F	Left	Screws and K-wires	46	153	Lateral condyle and capitellum	Posterior	Iliac crest
2	F	Right	ORIF	67	37	Lateral supra- and intra-condylar	Posterior	None
3	M	Left	Cast	18	91	Capitellum and trochlea	Lateral	Iliac crest
4	F	Left	Screws and K-wire	54	117	Capitellum and trochlea	Medial and lateral	Morselized bone graft
5	F	Right	Screws and K-wire	24	105	Medial column, trochlea andcondyle	Posterior	Iliac crest
6	F	Left	Extern fixation	48	26	Lateral condyle and capitellum	Posterior	None

F: Female; M: Male
ORIF: Open Reduction Internal Fixation

indications and practical guidelines for pre- operative planning and surgical techniques. We also documented the surgical outcome with long-term results of six cases with osteotomy for distal humerus malunion.

Materials and Methods

Patient characteristics

For this study we included six consecutive patients operated for intra-articular distal humerus malunion between 1992 and 2010 from two hospitals [Table 1]. There were five females and one male with a mean age of 42 years (range 16-67 years) at the time of corrective surgery. The mean interval between trauma and corrective osteotomy was 10 months (median 8 months; range 4-19 months). The mean follow-up time was 88 months (median 98 months; range 26-153 months). All patients were invited for a long-term follow-up assessment and were followed according to the same protocol: standardized questionnaires, physical examination, AP and lateral radiographs. The initial follow-up results of three patients where previously published as a case report, in a chapter and one patient was previously included in another case series (7-9). As these cases are so rarely presented and published, it was felt that including them in this series would be of additional value for the literature. The respective institutional review boards approved the current retrospective study and informed consent was obtained from all patients.

Figure 1. Pre-operative radiograph of the elbow with malunion.

Pre-operative planning

The indication for correction included stiffness, pain and deformity as delinead on both standard radiographs and computered tomography; and the absence of advanced articular loss or osteoarthritis (9).

A preoperative examination should document the range of motion of the elbow, the neurovascular status, skin condition including previous scars and evidence of infection. Most often standard AP and lateral radiographs will suffice for the diagnosis [Figure 1]. Nowadays 3D CT scanning can help pre-operative planning. Previous operative notes should be obtained and scrutinized for type of approach used, the position of the ulnar nerve and type of implants used.

Surgical technique

For access to both medial and lateral aspects of the distal humerus the patient is positioned in the lateral decubitus position on a bean bag. A sterile tourniquet will increase the surgical field and is inflated prior to incision. If iliac crest bone graft will be harvested this area is draped separately. The arm is placed across the chest over a blanket roll. Other positions can be prone (generally less favored by anesthesia) or supine with the arm extended on an arm table. The supine position is better when only a lateral or medial approach is anticipated. The surgeon and assistant are each on one side of the arm.

A straight midline posterior approach is universal and allows wide exposures of the entire elbow by creating medial and lateral skin flaps. If possible previous scars are incorporated in the incision. If the deformity is lateral, such as seen after coronal shear fractures, we use an extended lateral approach (10). However, the approach depends on the deformity that needs to be corrected (11). In four patients posterior approach was used. One patient had a lateral approach and one patient had a lateral and medial

Table 2. Elbow function and scores

	Preoperative	Postoperative	Improvement	*P*-value
Flexion (°)	103	123	19	0.10
Extension (°)	-58	-25	33	0.01
Flexion-extension arc (°)	48	98	50	0.02
Pronation-supination arc (°)	160	163	3	0.83
	mean	median	Range	
DASH score	12	6	0 - 40	
Mayo index score	94	95	80 - 100	

approach. The ulnar nerve is identified and protected with a vessel loop. An external neurolysis can be done using loupe magnification if ulnar neuropathy is present. This was done in one patient (case 4), which had severe ulnar neuropathy. Regardless of whether or not an anterior transposition is done at the end of the procedure we generally release the intermuscular septum proximally to increase mobility of the nerve. The ulnar nerve is released distally until it disappears in the flexor carpi ulnaris. The first branch of the ulnar nerve is to the joint and can be sacrificed (12).

After olecranon osteotomy the triceps is reflected of the distal humerus with a periosteal elevator or finger-dissection. Capsular release is done anteriorly and/or posteriorly. Synovial tissue is removed to better identify the exact anatomy. All previous hardware is generally removed. Broken screws only need to be removed if they preclude the anticipated correction. Based on the pre-operative plan K-wires are placed strategically to outline the correction osteotom(y)(ies). Intra-articular osteotomies were done through what seemed to be previous fracture lines although these might be difficult to discern. It might not be possible to exactly recreate the normal anatomy of the distal humerus. Once the desired correction is obtained fixation is done with plates and screws. Locking screw technology might provide better fixation in osteoporotic bone. Pre-contoured plating systems are costly but can save significant time otherwise lost to contouring standard plates. However, these precontoured plates are made for "normal" anatomy which is seldom restored in complex corrective procedures. Smaller and low profile type locking plates might prevent crowding of screws. Occasionally, a third plate may need to be added to augment stability of fixation. Before fixing the olecranon osteotomy the elbow is taken through a gentle testing of ROM and stability of fixation. The olecranon osteotomy is repaired with a tension band construct or a plate. Hemostasis is obtained after release of the tourniquet. The ulnar nerve is placed in a tension-free environment. Anterior transposition was done in only one patient (case 4) with severe pre-operative ulnar neuropathy.

Post-operative management

The elbow is splinted for a few days after which gentle active gravity assisted range of motion exercises can be started. When the wound has healed the patient is encouraged to use the arm for basic activities. Full activities are allowed after fracture healing is noted radiographically. Radiographs are obtained directly post-operatively, at 6 and 12 weeks.

Evaluation and statistical analysis

During the final follow up, patient's elbow function was assessed according to standardized questionnaires and classification systems. We used the standardized form for assessment of the elbow developed by the Research Committee of the American Shoulder and Elbow Surgeons (13). The form is divided in two sections: the patient self-evaluation and physician assessment. In the self-evaluation, patients were asked about pain of the elbow (range 0-10), function (range 0-3) and satisfaction with the surgery (range 0-10). In the physician assessment, an independent examiner who was not involved in the treatment of the patient assessed motion, stability (range 0-3). In addition, a list of possible physical findings is listed for the examiner to record abnormalities. We measured range of motion using a goniometer. We performed statistical analysis of pre-operative and post-operative measurement of range of motion with the paired t-test and calculated the P-value. The patients also filled out the disability/symptom section of the Disabilities of the Arm, Shoulder and Hand (DASH) outcome measure (range 0-100) and the Mayo Clinic Performance Index for the Elbow (range 0-100) (14, 15). Finally, one-tailed Pearson and Spearman correlations were performed

Figure 2. Follow-up radiograph, 16 months after correction osteotomyIntroduction.

(for continuous and categorical data, respectively) to test which parameters were predictors of functional outcome. Since the elbow function decreases in elderly patients, one-tailed analysis is justified.

Radiographs were graded for antecurvation/recuvation and varus/valgus angulation and elbow osteoarthritis by the senior author (PK) [Figure 2]. The extent of elbow osteoarthritis was rated following the Broberg and Morrey scoring system as Grade 0 (normal joint), Grade 1 (slight joint-space narrowing with minimal osteophyte formation), Grade 2 (moderate joint-space narrowing with moderate osteophyte formation), or Grade 3 (severe degenerative change with gross destruction of the joint) (16).

Results

All patients healed their osteotomies. We did not see any evidence of osteonecrosis. Three patients had postoperative complications. One patient (case 5) developed temporary sensory and motoric deficit of the medial nerve. One patient (case 2) developed an ulnar neuropathy, which was successfully treated with subcutaneous ulnar nerve transposition. One patient (case 3) had a deep wound infection with Staphylococcus Aureus six weeks postoperatively followed by infections with an Enterobacter Aerogenes and Escherichia Coli. It was successfully treated by early hardware removal after healing serial irrigation and debridement, and intravenous antibiotics. Four patients underwent hardware removal, because of irritation.

Range of motion improved significantly (P=0.02) [Table 2]. Notably, in the subgroup of patients with severe pre-operative flexion-extension arc (≤30 degrees), the arc increased with an average of 73 degrees. Unfortunately, there was no documentation available whether the capsular release by itself increased the range of motion.

All patients were satisfied during last assessment. [Table 2]. All were able to perform their daily activities. Correlation analyses showed a one-tailed strong relationship between age during corrective osteotomy, elbow function and long-term functional outcome (post-operative flexion-extension arc r= -0.74, P<0.05, ASES r = -0.78, P<0.05). There was no significant correlation between the amount of delay of corrective osteotomy and functional outcome.

Radiographic osteoarthritis of the elbow was present in four patients at final follow-up. One patient had a distal humerus recurvation of 20°. Correlation analysis showed a significant relation between level of osteoarthritis and post-operative flexion-extension arc (r=-0.79 and, P<0.05). There was no significant correlation between osteoarthritis and MEPI or DASH score.

Discussion

There is limited information on corrective osteotomies for distal humeral malunions in adults. A study by McKee et al, in 1993 measured elbow function after intra-articular corrective osteotomy for a malunion or nonunion. There were only two malunions that underwent intra-articular osteotomy and there was only a short-term follow up of 25 months (5). A few case reports are published that specifically address corrective osteotomy to treat distal humerus malunion (6, 7, 17). To the best of our knowledge, only one retrospective study investigated the long-term results of corrective osteotomy for malunion of the distal humerus in adults. However, that study did not analyze the correlation of pre- and post-operative findings (9). We attempted to fill this lack of available literature by assessing the function of the elbow and the quality of life using standardized and validated questionnaires with a mean follow-up of 88 months.

There is no question that major articular incongruity has direct implications on development of early degenerative osteoarthritis (5, 18). Because of the missing pre-operative radiographs, we could not exclude further progress of osteoarthritis. However, absence of progressive pain and decreasing motion suggests that there was no further progress of osteoarthritis. Realignment by an osteotomy before arthritis sets in might be considered, rather than prosthetic replacement. The decision for corrective osteotomy is not easy and needs careful consideration and discussion with the patient. Possibly, referral to an expert should be considered.

The limitations of the present study include its retrospective nature, the small number of patients, missing information on the initial trauma and the wide range of duration of follow-up. Therefor, statistical analyses should be interpreted with caution.

Moreover, we made radiographic measurements on plain radiographs, with an inherent risk of limited interobserver reliability. Incomplete preoperative documentation including radiographs and elbow scores, pain score, ulnar nerve symptoms and strength measurements made it impossible to compare pre- and post-operatively. Furthermore, the DASH score of one patient was missing.

In this series of six patients with an intra-articular malunion of the distal humerus, it was shown that a successful corrective osteotomy improved elbow function, reduced pain and provided a high satisfaction rate. Although complication rate of corrective osteotomy was high (3/6), all complications could be treated successfully in this cohort. Surgeons and patients should be aware of the potential requirement for additional surgical procedures such as ulnar nerve release and hardware removal. In the author's opinion, an intra-articular corrective osteotomy should particularly be considered in young patients with minimal osteoarthritis and moderate to severe functional disability and/or pain.

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