Contoured plating for proximal ulna nonunion: an improved technique

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Abstract Twenty-one patients having proximal ulna nonunion were treated with contoured plating. The most proximal hole received an intramedullary 6.5-mm cancellous lag screw that extends fixation of the nonunion site. Mean age of the patients was 41.7 years. Average follow-up period was 22 months. Union occurred in 19 cases after a mean of 9.6 weeks. Complications were persistent nonunion in two cases, a stiff elbow in one, hardware prominence in two, and a 1×1-cm ulcer over the curve of the plate in one case. The two unsatisfactory results were related to ulnohumeral arthritis. In conclusion, augmentation of the contoured plate with a 6.5-mm intramedullary cancellous lag screw creates a stable construct in treatment of proximal ulna nonunion. It applies axial compression, resists bending forces on the dorsal plate and allows early mobilization after surgery, regardless of the size of the proximal fragment.

Introduction

Proximal ulna non-union is a rare complication that leads to restriction of elbow and forearm movement and, consequently, reduced function and stability [1–4]. This complication may result from the difficulty in maintaining an acceptable alignment using closed treatment or after failure of internal fixation in complex injuries, such as Monteggia injuries or association with fractured head of the radius. Additional risk factors include open injuries, infection, comminution and compromised vascularity [3, 5].

Plating plus bone grafting is the treatment of choice for nonunion at that site [1–6]. The Ilizarov technique is mainly indicated in cases with atrophic nonunion with bone loss [7].

Plating a proximal ulna ununited fracture presents unique surgical challenges including fixation of a small proximal fragment with mostly unicortical screws in an usually osteoporotic area [6]. Straight or contoured small fragment semitubular and reconstruction plates have been associated with occasional fatigue failure related to the extreme bending stress at the proximal ulna under flexion forces. This bending stress is accentuated with a deficient anterior cortex due to fracture coronoid or anterior cortical comminution [7]. The greater strength of the dynamic compression plates makes implant failure less likely; but perfect contouring of this implant to fit the anatomy of the proximal ulna is difficult. This may result in an inadequate number of proximal screw holes or excessive hardware prominence under the soft tissue [6, 7].

Another potential complication of plating is injury to the ulnar artery or median nerve by the drill bit if introduced more than 1 cm beyond the anterior ulnar cortex at a distance of up to 1.5 cm distal to the coronoid [8].

This article presents an improved technique of large fragment semitubular contoured plating to treat proximal ulna nonunion.

Patients and methods

Patients

From December 2003 to March 2008, 21 cases of ununited proximal ulnar fractures were included in this prospective study. All patients gave informed consent to be included in the study. Cases with painless stiff nonunion with a stable

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Table 1 Pertinent data from the study

Patient	Age/ gender	Initial injury (Bado classification)	Previous fixation	Timing of surgery (month)	Complications	Added surgery	Time of union (wks)	Broberg- Morrey Score
1	27/M	Type 1	1/3 tubular plate	13			10	Excellent
2	31/M	Type 4	Reconstruction plate	9	Ulcer 1x1 cm over olecranon tip	Hardware removal	12	Good
3	52/F	Type 2	Small fragment DCP	8			10	Good
4	55/M	Type 2	1. Tension band wiring+excision head radius2. Precontoured olecranon plate+bone graft	21	Grade 3 arthritis		12	Fair
5	62/F	Type 2	1/3 tubular plate	7			8	Excellent
6	54/F	Type 1	Small fragment DCP	11	Hardware prominence	Hardware removal	10	Good
7	36/M	Type 1	Small fragment DCP	8	Hardware prominence	Hardware removal	12	Good
8	42/M	Type 4	Small fragment DCP	10			12	Excellent
9	29/M	Type 2	1/3 tubular plate	8	Persistent nonunion	Bone graft	24	Good
10	59/M	Type 1	Reconstruction plate	12	Persistent nonunion	Bone graft	24	Good
11	31/F	Type 2	1/3 tubular plate	9			12	Excellent
12	28/F	Type 1	Small fragment DCP	15			10	Excellent
13	63/M	Type 2	1/3 tubular plate	8			12	Good
14	21/M	Type 4	1. Tension band ulna+1/3 tubular plate radius2. Reconstruction plate ulna+bone graft	16	Grade 3 arthritis	Capsular release	10	Poor
15	56/M	Type 4	1/3 tubular plate	13			8	Good
16	38/M	Type 1	1. Reconstruction, plate2. Small fragment DCP	7			10	Good
17	43/F	Type 2	1. Tension band wiring2. 1/3 tubular plate+bone graft	11			12	Good
18	40/M	Type 1	1/3 tubular plate	7			10	Good
19	37/F	Type 1	1/3 tubular plate	7			10	Excellent
20	41/M	Type 2	Reconstruction plate	9			12	Excellent
21	30/M	Type 2	Small fragment DCP	11			12	Excellent

M male, *F* female, *DCP* dynamic compression plate

elbow having a range of movement greater than 90° were excluded. Fifteen patients were male and six were female. Ages ranged from 21 to 63 years (mean 41.7) (Table 1). The right side was affected in nine cases (all dominant) and the left in 12 cases (one dominant). The cause of trauma was fall on the outstretched hand in 14 cases and road traffic accident in seven cases. According to the Bado classification [9], the original injury was type 1 Monteggia (anterior) fracture in eight cases, type 2 (posterior) in nine cases, and type 4 (with radial shaft) in four cases (Table 1). All were closed injuries. Four cases with type 2 Monteggia had radial head fractures, involving more than 50% of the circumference, and were treated with early excision which led to posterior radial shaft subluxation at its proximal end. The coronoid process was fractured in one of these four cases. One patient with a type 4

injury had associated ipsilateral minimally displaced fracture of the lateral condyle of the humerus that was treated conservatively. Seventeen patients had one previous operation and four patients had undergone two, and implant failure accompanied nonunion in all cases. Infection was excluded in all cases. Nonunion was hypertrophic in 13 cases and atrophic in eight cases. None had associated neurovascular injuries. One patient had polyarticular rheumatoid arthritis with bilateral arthritic and partially stiff elbows.

Methods

The operations were undertaken after a period ranging from seven to 21 months (mean 10.5) from the original trauma. The patient was positioned supine with the affected arm

Fig. 1 **a** Left arm of a 27-year-old man who sustained a type 1 Monteggia injury after a fall (13 months previously). Nonunion with broken 1/3 tubular plate is shown. **b** X-ray four months after contoured plating and bone grafting showing union. He had an excellent functional result according to Broberg and Morrey score

across the chest. The ulna was exposed along the old incision and extended as required. The ulnar nerve was exposed and protected. All hardware was removed. After freshening and aligning the fragments, the medulla was drilled with a 4.5-mm drill bit from the tip of the olecranon through the fracture site, into the distal fragment, followed by 6.5-mm tapping up to 3 centimetres distal to the fracture site. An intramedullary 6.5-mm partially threaded (16 mm) screw was assembled with a contoured large fragment semitubular plate (Fig. 1). The length of the screw was that of the proximal fragment plus 3 cm to allow sufficient passage of the threads into the distal fragment, and the plate long enough to allow three holes distal to the screw tip. The plate was applied to the dorsal aspect of bone, wrapped around the olecranon and the intramedullary screw was inserted through the most proximal hole of the plate and advanced to fix and compress the fracture site. Three point fixation is achieved when the screw crosses the proximal ulnar varus angle (Fig. 2). The mean value of this angle is 17.5°, located at 76 mm average distance from the olecranon tip [10]. The three cortical screws were then applied distal to the lag screw. In 18 patients an iliac crest bone graft was applied to the fracture site. In the remaining three cases, the defects were judged too small to justify

Fig. 2 **a** The proximal varus angle of the ulna. **b** The intramedullary screw achieving a three point fixation

bone grafting. The wound was closed after meticulous haemostasis. It had been planned to use an intercalary tricortical iliac graft or to use the Ilizarov technique in cases with massive bone resorption to guard against ulnar shortening and radioulnar instability. Such cases were not encountered in this study.

A posterior slab was applied for two weeks. Light daily activities were then allowed within an arm sling until radiological signs of union appeared. Range of motion and strengthening exercises followed.

Patients were examined clinically and radiologically every two weeks until union, and then every three months until the end of the follow-up period (12–36 months, mean 22).

Functional outcomes were calculated using the Broberg-Morrey [11] scoring system. This system assigns a percentage value to the elbow performance based on pain, stability, motion and performance. A total score of 90–100 points is considered excellent, 80–89 points is good, 60–79 points is fair, and less than 60 points is poor. Fair and poor results were considered unsatisfactory.

Radiographs were evaluated for union, articular congruity and alignment. Radiographic signs of arthritis were graded according to the system of Broberg and Morrey [11]: grade 0, normal elbow; grade 1, slight joint space narrowing with minimal osteophyte formation; grade 2,

moderate joint space narrowing with moderate osteophyte formation; and grade 3, severe degenerative changes with gross destruction of the joint.

Results

Operative time ranged between 45 and 55 minutes; the mean length of the intramedullary screw was 93.8 mm (85–105 mm) and the plate ranged from 10–13 holes. Union took place in 19 cases after the index surgery after 8–12 weeks (mean 9.6). The average arc of elbow flexion at the final evaluation was 103° (range 60–130°). The average arc of forearm rotation at the final evaluation was 127°

(range 50–150°) with an average pronation of 62° (range 20–70°) and average supination of 65° (range 30–80°).

At the end of the follow-up period (mean 22 months), eight cases were rated excellent, 11 were good, and two had unsatisfactory results (one fair and one poor). The unsatisfactory results were related to painful arthritis (Fig. 3), and the difference was statistically significant ($p=0.034$). There were no statistically significant relations between the final score and initial fracture type ($p=0.399$), number of previous operations ($p=0.062$), or the timing of surgery ($p=0.143$).

Complications and additional surgeries

Persistent nonunion without implant failure was considered 16 weeks post surgery in two out of the three cases in which bone graft was not applied, but both united with bone grafting after another eight weeks. One patient was subjected to capsular release for a stiff elbow six months after the index operation, and this improved the flexion arc from 20–60° at the final follow-up period (18 months for that patient).

Five patients showed radiographic signs of ulno-humeral arthritis, rated as type 1 in three patients, and type 3 in the two patients who had the unsatisfactory results (one fair and one poor). The fair result came in a patient with bilateral rheumatoid arthritis of the elbows (Fig. 3), and the poor result was in a patient who sustained an associated ipsilateral lateral humeral condyle fracture with subsequent arthritis and stiffness.

Six patients noticed hardware prominence at the elbow, and two of them complained of it and had their hardware removed after a mean of 7.2 months. One patient developed a 1 cm x 1 cm ulcer over the curve of the plate at the olecranon tip after 12 weeks. This was managed conservatively, without infection, for an additional four weeks when the hardware was removed after full consolidation of the fracture, and the ulcer healed soon afterwards.

Deep infection, ulnar neuritis and metal failure were not recorded.

Discussion

Some technical errors in the management of proximal ulnar fractures are blamed for the development of nonunion. These include casting an unstable fracture, plating with an insufficient number of screws in the proximal fragment, and underestimation of a coronoid fracture or an anterior cortical comminution as a stress riser on a dorsally applied plate [3, 5, 6]. Other factors include treating a very proximal Monteggia fracture as an olecranon fracture with an insufficient tension band wiring or an intramedullary screw, and early excision of the head of the radius before consolidation of the ulna [3, 6]. In most of these situations,

Fig 3 **a** Left arm of a 55-year-old rheumatoid patient who sustained a type 2 Monteggia injury with radial head fracture after a fall. X-ray shows a small proximal fragment, nonunion, radial shaft subluxation and an additional distal fracture over screw tip. **b** A precontoured olecranon plate plus bone graft was applied. Both sites did not unite and the plate failed at both locations after another trivial trauma. **c** X-ray three months after contoured plating and bone grafting showing union at both sites. He received a fair functional result according to Broberg and Morrey scoring

bone grafting plus revision plating with the same rationale would eventually be doomed to failure.

Our new method augments the contoured plate with an intramedullary 6.5-mm cancellous lag screw. The screw is intended to axially compress the fracture site, while simultaneously stress shielding the plate against angulatory forces. The screw potentially adds to the stability of fixation by traversing the normal proximal ulnar varus angle [10], achieving a three-point fixation after reaching strong cortical bone.

The application of the plate on the dorsal surface of the ulna functions more effectively as a tension band under flexion forces [12]. The large fragment semitubular plate was used to accommodate the 6.5-mm lag screw and allow contouring around the olecranon and over the curved metaphyseal-diaphyseal junction. No screws were inserted into the proximal fragment beside the intramedullary one and this safeguarded against potential neurovascular injuries by a drill bit if introduced more than 1 cm beyond the anterior ulnar cortex at a distance up to 1.5 cm distal to the coronoid [8]. The problem of poor fixation of a small and/or osteoporotic proximal fragment is overcome by the assembly used in this study. The fixation depends on the intramedullary purchase of the lag screw into a cortical area, in addition to the plate and three screws, no matter how small and/or porotic the proximal fragment is.

Metal failure after internal fixation for nonunion proximal ulna was reported by Ring et al. in 2004 [6] using contoured plating and by Rotini et al. in 2008 [3] using a straight reconstruction plate. In this study, implant failure was not encountered in any cases, and the two cases showing persistent nonunion eventually united after bone grafting as a secondary procedure over a stable construction. The augmented construction is thought to achieve this high rate of union, and to combat implant failure in the two cases having refractory nonunion.

The unsatisfactory results were related to painful elbow arthritis. In one case, the elbow was already arthritic in the course of polyarticular rheumatoid arthritis and the trauma involved a very proximal type 2 Monteggia lesion, a coronoid fracture and a radial head fracture. The other case sustained an associated ipsilateral lateral humeral condylar fracture, predisposing to secondary arthritis. Stable internal fixation of the ulna and associated humeral fractures plus early motion would have a role in preventing the

development of arthritis [6]. The same principle applies to the head of the radius, as replacement or fixation would buttress the unstable ulna fracture in addition to preventing radial shaft subluxation [3, 6].

In conclusion, the augmentation of the contoured plate with a 6.5-mm intramedullary cancellous lag screw creates a stable reconstruction in the treatment of proximal ulna nonunion. It applies axial compression, resists bending forces on the dorsal plate and allows early mobilisation after surgery, regardless of the size of the proximal fragment.

Conflict of interest statement The authors declare that they have no conflict of interest related to the publication of this manuscript.

References

1. Ring D, Jupiter JB, Gulotta L (2003) Atrophic nonunions of the proximal ulna. *Clin Orthop Relat Res* 409:268–274
2. Egol KA, Tejwani NC, Bazzi J, Susarla A, Koval KJ (2005) Does a Monteggia variant lesion result in a poor functional outcome? A retrospective study. *Clin Orthop Relat Res* 438:233–238
3. Rotini R, Antonioli D, Marinelli A, Katusić D (2008) Surgical treatment of proximal ulna nonunion. *Chir Organi Mov* 91(2):65–70
4. Simpson NS, Goodman LA, Jupiter JB (1996) Contoured LCDL plating of the proximal ulna. *Injury* 27(6):411–417
5. Papagelopoulos PJ, Morrey BF (1994) Treatment of nonunion of olecranon fractures. *J Bone Joint Surg Br* 76(4):627–635
6. Ring D, Tavakolian J, Kloen P, Helfet D, Jupiter JB (2004) Loss of alignment after surgical treatment of posterior Monteggia fractures: salvage with dorsal contoured plating. *J Hand Surg [Am]* 29(4):694–702
7. Smith WR, Elbatrawy YA, Andreassen GS, Philips GC, Guerreschi F, Lovisetti L, Catagni MA (2007) Treatment of traumatic forearm bone loss with Ilizarov ring fixation and bone transport. *Int Orthop* 31(2):165–170
8. Prayson MJ, Iossi MF, Buchalter D, Vogt M, Towers J (2008) Safe zone for anterior cortical perforation of the ulna during tension-band wire fixation: a magnetic resonance imaging analysis. *J Shoulder Elbow Surg* 17(1):121–125
9. Bado JL (1967) The Monteggia lesion. *Clin Orthop Relat Res* 50:71–86
10. Wang AA, Mara M, Hutchinson DT (2003) The proximal ulna: An anatomic study with relevance to olecranon osteotomy and fracture fixation. *J Shoulder Elbow Surg* 12(3):293–296
11. Broberg MA, Morrey BF (1986) Results of delayed excision of the radial head after fracture. *J Bone Joint Surg Am* 68(5):669–674
12. Radin EL, Blaha JD, Rose RM, Litsky AS (1992) Practical biomechanics for the orthopaedic surgeon. New York, Churchill Livingstone, pp 86–87