Solitary ulnar shortening osteotomy for malunion of distal radius fractures: Experience of a centre in the UK and review of the literature

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ABSTRACT

INTRODUCTION Isolated ulnar shortening osteotomies can be used to treat ulnocarpal abutment secondary to radial shortening following distal radius fractures. Given the increase of fragility distal radius fractures awareness of treating the sequelae of distal radius fractures is important. We present the largest reported case series in the UK of ulnar shortening osteotomies for this indication.

MATERIALS AND METHODS Twenty patients with previous distal radial fractures were included, who presented with wrist pain and radiologically evident positive ulnar variance secondary to malunion of the distal radius with no significant intercalated instability. Patients were treated with a short oblique ulnar shortening osteotomy, using a Stanley jig and small AO compression plate system. Pre- and postoperative radiographical measurements of inclination, dorsal/volar angulation and ulnar variance were made. Patients were scored pre- and postoperatively using the Quick Disabilities of the Arm, Shoulder and Hand (Quick-DASH) and Patient-Rated Wrist Evaluation scores by two orthopaedic surgeons. Mean follow-up was 24 months after surgery.

RESULTS Radiographical analysis revealed a change in the ulnar variance with an average reduction of 5.74 mm. Mean preoperative scores were 61.1 (range 25–95.5) for QuickDASH and 70.4 (range 33–92) for Patient-Rated Wrist Evaluation. At the latest follow-up, mean postoperative QuickDASH scores were 10.6 (range 0–43.2) and 17.2 (range 0–44) for Patient-Rated Wrist Evaluation. Differences in scores after surgery for both QuickDASH and Patient-Rated Wrist Evaluation were statistically significant ($P < 0.01$).

CONCLUSIONS The ulnar shortening osteotomy is a relatively simple procedure compared with corrective radial osteotomy, with a lower complication profile. In our series, patients showed significant improvement in pain and function by correcting the ulnar variance thus preventing ulna–carpal impaction.

KEYWORDS

Ulnar shortening – Malunited distal radius – Ulnar impaction syndrome

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Introduction

Fractures of the distal radius are among the most frequent pathologies encountered by the emergency and orthopaedic department. Vast amounts of literature are available on the management of these injuries.²⁴ The UK Distal Radius Acute Fracture Fixation trial continues to provoke great debate in the orthopaedic community and has already influenced surgical management of these fractures nationally.¹ This has led to a sharp rise (42% vs 12%) in Kirschner wire fixation for dorsally displaced distal radius fracture since the publication of the paper.² This is pertinent because, although short-term functional outcomes

were comparable with plate fixation, radiological outcomes were better in the plating group at 12month follow-up. The Kirschner wiring group had a larger (more positive) dorsal tilt and ulnar variance that was statistically significant. This is in keeping with other studies where, despite surgical intervention, malunion is reported in 11% of cases, with rates of 23% described in non-operative cases.³

Symptomatic malunion of distal radius fractures can lead to significant morbidity in patients. Post-traumatic ulnar impaction syndrome is a common complication following distal radius fracture.²⁰ Pain and reduced grip strength are usually the main complaints. A thorough clinical and radiological assessment with focus on the desired

functional requirement of the patient is essential before considering surgical management. Numerous surgical management options are available; corrective radial lengthening and ulnar shortening osteotomies, distal ulnar resection (Darrach's procedure), hemi-resection, interpositional arthroplasty, Sauve-Kapandji procedure and distal radioulnar joint replacements.²⁵

There is a relative paucity in the literature studying functional outcomes following these procedures. Ulnar shortening osteotomies are technically simple procedures with low complication rates. The aim is to prevent ulna-carpal abutment and to restore distal radioulnar joint congruity. Favourable functional outcomes have been reported in most patients at mid-term follow up. We present a case series of 20 patients on the use of the ulnar shortening osteotomy for malunited distal radius fractures presenting with ulnar impaction syndrome. To our knowledge, this is the largest documented series in the UK.

Objective

The aim of the study was to assess whether an ulnar shortening osteotomy produces any significant improvement in wrist pain and function in patients with malunited distal radius fractures.

Materials and methods

A total of 20 patients (9 male, 11 female) with an average age of 48 years (range 30–73 years) were included in this retrospective study. Nine (45%) patients were right-hand dominant and 11 (55%) fractures were in the dominant wrist. All procedures were performed between March 2005 and November 2009. The inclusion criteria of the study were patients who had previously had a distal radius fracture and presented with clinical signs of ulnar-sided wrist pain and a radiological positive ulnar variance. Patients under the age of 18 years were excluded. The ulnar variance was measured using the description by Steyers and Blair.⁴ There was no significant intercalated segment instability on plain radiographs. In keeping with other studies, malunions with greater than 20 degrees deformity in both volar and dorsal angles were excluded.^{5–8} It was thus thought that deformities greater than this value would benefit from a corrective radial osteotomy. Data were also collected on hand dominance, date of initial injury, date of surgery and date of last follow-up. The procedure was performed by the senior author or trainee registrar under his direct supervision.

Plain radiographs of the wrist were assessed using the picture archiving and communication system. All radiological assessments for the study were performed by two orthopaedic surgeons. Pre- and postoperative measurements of radial height (mm), volar/dorsal angulation (degrees) and ulnar variance ($\pm$ mm) were evaluated. Functional outcomes were assessed using the Quick Disabilities of the Arm, Shoulder and Hand (QuickDASH) and Patient-Rated Wrist Evaluation (PRWE) questionnaires before and after the procedure. The PRWE score has not been used in similar studies but is rated the most

responsive functional outcome score post-distal radius fractures and thus used additionally.⁹

Statistics

The mean pre- and postoperative ulnar variance and radial height was calculated using Microsoft Excel. The Wilcoxon signed rank test and paired t-tests (using SPSS v19) were used to compare the QuickDASH and PRWE scores and radiological measurements. The level of statistical significance was assigned at $P < 0.05$.

Surgical technique

Under general or regional anaesthesia and with an arm tourniquet, the patient was placed supine with an arm board extension used for the operative table. The ulna was approached directly with care taken to protect the dorsal sensory branches of the ulnar nerve. The interval between the flexor carpi ulnaris and extensor carpi ulnaris was developed. The periosteum was evaluated with sharp dissection and the osteotomy site was identified with the image intensifier in keeping with the preoperative planning. A short oblique osteotomy was performed using an oscillating saw. Using the Stanley Jig, a measured bone resection was completed dependent on the amount of positive ulnar variance preoperatively. The ulna was subsequently stabilised with the six-hole small fragment AO compression plate on the volar surface. An intrafragmentary cortical screw was used in most cases to increase the stability of the construct. The wound was closed in layers and the arm placed in a functional below-elbow slab for two weeks. The wound was evaluated in the outpatient clinic at which point a radiograph was obtained and a full below-elbow cast applied. At six-week follow up, gentle mobilisation was encouraged and further rehabilitation guided by radiological union.

Results

Twenty patients underwent an ulnar shortening osteotomy for ulna-sided wrist pain following a malunited distal radius fracture. The average time from time of initial fracture to intervention was 30 months. Patients were followed-up for an average of 24 months (range 10–72 months). The average radial height (Fig 1) was 7.3 mm and radial angulation was +3.9 degrees (range –5 to +16 degrees).

Preoperatively, the ulnar variance was +5.28 mm (range 3.0–10.1). Postoperatively, the ulnar variance measurements had decreased in all patients (–0.46 mm, a difference of 5.74 mm) with radiographs confirming a congruent distal radioulnar joint. The mean ulnar resection was 5.7 mm (range 2.2–12.6 mm). Radiological outcomes when the ulnar variance became more 'normalised' correlated with the functional outcome scores with statistically significant improvements in both PRWE and QuickDASH scores (Table 1). The mean time to union could not be calculated given the retrospective study design and variation in follow-up clinic appointments of these patients.

Only one complication was noted in our case series, which was a metalwork failure due to a deep infection. This required debridement, metalwork removal, a course of intravenous antibiotics and immobilisation in an above-elbow cast. The osteotomy proceeded to radiological union and the patient eventually had a good functional outcome. No other patients required metalwork removal in the follow-up period investigated. This research received no financial grant from any agency in the public, commercial or non-profit sector

Discussion

Functional outcomes can be significantly impaired following a distal radius fracture. This is often due to a relative lengthening of the ulna secondary to a shortened healed radius causing ulnar impaction syndrome. Cowie *et al* retrospectively reviewed 521 patients treated for distal radius fractures and investigated the factors predicting function. Among the predictors dorsal angulation and positive ulnar variance were associated with poorer functional outcomes scores.¹⁰ Biomechanically this can be explained by the change in load transmission at the wrist. A small rise of 2 mm in ulna length can result in increasing the ulna load to 40%.¹⁶

Ulnar impaction syndrome was first described by Milch in 1941 with its aetiology secondary to a malunited Colles fracture.^{11,12} Since then, the indications for an ulnar osteotomy have widened and it is currently used for a range of pathologies that provoke ulna–carpal abutment including premature physal arrest, Madelung's deformity and triangular fibrocartilage complex tears. In current practice, the vast majority of procedures are being performed for

Table 1 Pre- and postoperative Patient Related Wrist Evaluation and Quick Disabilities of Arm, Shoulder and Hand scores.

Questionnaire	Preoperative score	Postoperative score
PRWE	70.4	17.2
QuickDASH	61.1	10.6

PRWE, Patient Related Wrist Evaluation; QuickDASH, Quick Disabilities of Arm, Shoulder and Hand.

Idiopathic ulnar impaction syndrome.^{8,13,14} In their case series of 63 patients over 10 years, Chan *et al* performed 49 ulnar shortening osteotomies (78%) for ulnar impaction syndrome with only 9 for distal radius fractures.¹⁵ This is in keeping with our literature review where only five studies were found to investigate the outcomes (radiological or functional) of shortening the ulna exclusively following malunion of distal radius fractures. The PubMed database was searched using the keywords 'ulnar shortening osteotomy' and/or 'distal radius fracture malunion'. The search identified further studies that used the ulnar shortening osteotomy for ulnar impaction syndrome. However, these studies did not stratify the data of patients with previous distal radius fractures from those with idiopathic ulnar impaction syndrome,^{8,13,15,17,27} and hence were excluded from our analysis (Table 2).

All the studies compare favourably with our results, with most patients showing good functional outcomes after short- to mid-term follow-up. Additionally, Fricker *et al* reviewed their outcomes following 'post traumatic' ulnar impaction syndrome of 30 patients (including 20 distal radius fractures) reporting high patient satisfaction rates in 89%.¹⁷ Complication rates were low among the six studies (including this one) treating ulnar impaction syndrome for malunited distal radius fractures with a solitary ulnar shortening osteotomy. Cumulatively, the rate of non-union was 6.1% (6 of 98 cases). Subsequent union was documented in all these cases following revision surgery.

Despite these encouraging results, clinicians must be careful when evaluating patients with ulnar impaction syndrome preoperatively. It is generally recommended that for a dorsal tilt greater than 20 degrees and volar malunion greater than 10 degrees an isolated ulnar shortening osteotomy should not be employed.¹⁸ Such severe, multi-directional deformities usually require a corrective distal radius osteotomy to replicate normal distal radioulnar joint biomechanics. This technique is still commonly used in milder deformities with most surgeons preferring an opening wedge osteotomy. Deterrence for the procedure is its large complication rate; Mulders *et al* reported an incidence of 38% in their series of 48, which included implant failure, extensor tendon ruptures and non-union. This is reinforced by other studies where even in the hands of an experienced surgeon postoperative tendon injuries and median nerve irritation is common.¹⁹ Aibinder *et al*

Table 2 Literature review of previous studies treating malunited distal radius fracture with isolated ulnar shortening osteotomy.

Study	Cases (n)	Osteotomy	Fixation type	Mean age (years)	Mean follow-up (months)	Functional outcome score used	Outcome	Complications
Oskam <i>et al</i> (23) (1993)	10	Transverse or oblique	6-hole small AO compression plate	48	36	Qualitative (good, fair or poor)	Good: 6 Fair: 2 Poor: 2	2 cases of non-union
Tatebe <i>et al</i> (2012)	16	Transverse	3.5 mm locking compression plate	48	72	Mayo wrist score	Excellent: 2 Good: 7 Fair: 6 Poor: 1	None
Srinivasan <i>et al</i> (2013)	18	Oblique	6- or 7-hole 3.5 direct compression plate (using Acumed or Rayhack cutting jigs for osteotomy)	53	34	Visual analogue pain score QuickDASH	VAS improved from 4.1 to 1.9 Quick DASH scores improved from 43 to 11	1 intraoperative fracture treated with plate repositioning 1 non-union treated with revision surgery
Löw <i>et al</i> (2014)	23	Plate	Type not mentioned	41.3	86.4	Modified Mayo DASH	Mayo: average 79.5 Excellent: 14 Good 5 Poor: 4 DASH: average 20.9	1 non-union
Aibinder <i>et al</i> (2017)	11	Transverse or oblique	Compression plate (Using Acumed, Rayhack or Trimed cutting jigs for osteotomy)	52.3	12.7	VAS	VAS improved from 5.1 to 2.0	1 non-union treated with revision surgery and autologous bone grafting

compared outcomes of an opening wedge distal radius osteotomy versus ulnar shortening osteotomy for this population group. No patients with a dorsal tilt of greater than 20.1 degrees were included in the study. Both cohorts showed improvement in range of movement, grip strength and pain scores with no statistically significant differences. They concluded that as ulnar shortening osteotomy is a usually a simpler, shorter procedure it should be considered as first-line treatment in patients with sagittal angulation of less than 20 degrees.²⁰ This is in keeping with our findings and supports the use of solitary ulnar shortening osteotomy for patients with ulnar sided wrist pain following distal radius fracture malunion.

Our study is not without limitations. As previous studies, it is of retrospective design and has short- to mid-term follow-up. The study also does not include further radiological review to identify distal radioulnar joint arthritis, which can be associated with an iatrogenic negative ulnar variance.²² Löw *et al* identified new radiological evidence of distal radioulnar joint arthropathy in 12 of their 25 patients at follow-up. Interestingly, only 1 of these 12 patients required subsequent treatment.

Additionally, no objective measure of wrist function was performed (range of movement and grip strength). We

believe that the range of movement assessment is not always a useful measure of functional outcome following distal radius fractures as, despite severe deformities, many patients can have a range of movement within acceptable limits. The range of movement of the wrist is considered functional if the flexion/extension arc is greater than 80 degrees and the combined radial/ulnar deviation arc is greater than 40 degrees.²¹ Most studies evaluated in this paper confirm this point as almost all patients in these studies have a 'functional' range of movement. Hence a validated functional outcome questionnaire was thought to be a more useful assessment tool. This is the strength of the study as patients were evaluated with both the QuickDASH and PRWE scoring systems. This is particularly salient given the impact of recent pragmatic trials in the orthopaedic literature which have predominantly based their conclusions on patient reported outcome data.^{1,26}

The study highlights the different options of treating symptomatic distal radius deformities and that good outcome can be achieved with an isolated ulnar shortening osteotomy whilst evaluating the current literature. Given the increase of fragility distal radius fractures in patients with higher functional expectations awareness of treating

the sequelae of distal radius fractures is important for orthopaedic surgeons.

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