Mid-Term Results Following Ulna Shortening Osteotomy

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Received: 24 July 2013/Accepted: 21 October 2013 /Published online: 14 November 2013
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Abstract *Background:* Successful short-term results of diaphyseal ulna shortening osteotomy are documented in both idiopathic and post-traumatic ulnar impaction. *Questions/Purposes:* The purpose of this study was to evaluate the mid-term outcomes of ulnar shortening osteotomy with respect to radiographic assessment of corrected alignment and healing as well as patient satisfaction, pain, and function assessed using the Disability of the Arm, Shoulder, and Hand (DASH) score. *Patients and Methods:* This retrospective case series included follow-up of 33 patients with ulnar impaction syndrome following ulna shortening osteotomy at a minimum of 5 years. Patient-rated outcomes included satisfaction, pain assessment, and DASH score. Pre- and postoperative radiographs were reviewed to quantify ulnar variance and osteotomy union rates. Subsequent operations were also recorded. *Results:* Average follow-up was 10 years (range, 5–20 years). Eighty-eight percent of patients reported they were either satisfied or very satisfied with the procedure and 91% reported they would have the same procedure again. Average pain rating was 2 out of 10 at final follow-up. The mean DASH score was 11 (range, 0–39). Removal of hardware was performed in 10 patients (30%). The overall rate of reoperation was 45%. *Conclusions:* Ulna shortening osteotomy yields reliable midterm satisfaction and pain relief in patients with idiopathic and post-traumatic ulnar impaction

syndrome. Reoperation is frequent. Consistent with results of short-term follow-up, plate irritation requiring removal remains the most common cause for reoperation over time.

Keywords ulna · impaction · shortening · osteotomy

Introduction

Diaphyseal ulna shortening osteotomy was first described in 1941 by Milch as treatment for “reversal of the normal relationships of the radial and ulnar styloids” resulting from malunion following distal radius fracture [10]. It is now a recognized treatment for any condition resulting in excessive loads across the ulnocarpal joint. These causes most commonly include distal radius malunion and idiopathic positive ulnar variance but may result from other conditions causing mechanical abutment of the distal ulna with the carpus [16]. Such mechanical alterations result in ulnar impaction syndrome, lead to progressive degeneration of the triangular fibrocartilage complex (TFCC), and may contribute to ulnar-sided wrist pain. While less-invasive treatments for ulnar impaction, including arthroscopic TFCC debridement or repair and arthroscopic wafer resection have been described, ulna shortening osteotomy remains a commonly performed procedure when conservative measures fail [2, 5, 16].

Early outcomes following ulna shortening osteotomy for the treatment of ulnar impaction syndrome have demonstrated good pain relief, satisfactory objective outcomes (motion, strength, and healing), and patient satisfaction [1, 4, 6, 12, 16]. The most commonly reported complications of ulnar shortening osteotomy are plate irritation (8–56%) and ulnar nonunion (approximately 5%) [2, 15, 18]. The longer-term outcomes following ulna shortening osteotomy are important given the biomechanical alterations on both the radiocarpal and distal radioulnar joint (DRUJ) that are expected following surgery. A biomechanical study demonstrated that increased peak pressures in the DRUJ correlated positively with the amount of ulna shortening [13]. If elevated peak pressures lead to progressive

Level of Evidence: Therapeutic Level IV, case series.

Electronic supplementary material The online version of this article (doi:10.1007/s11420-013-9371-7) contains supplementary material, which is available to authorized users.

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degenerative changes in the DRUJ postoperatively, the satisfaction, pain relief, and functional benefit seen in early follow-up may deteriorate over time.

The purpose of this study was to confirm that mid-term (>5 years) patient satisfaction, pain relief, and upper-limb function after ulna shortening osteotomy for the treatment of ulnar impaction syndrome are consistent with that seen in short-term follow-up. We also evaluated radiographs, complications, and secondary surgeries. Based on anecdotal experience, we hypothesized that the good satisfaction, pain relief, and upper limb function seen in earlier follow-up would be maintained over a longer term.

Patients and Methods

Following institutional review board approval for study, we queried our surgical billing database using the current procedural terminology code for ulna shortening osteotomy. Inclusion criteria were diagnosis of either idiopathic or post-traumatic ulna impaction syndrome, age 18 years or greater at time of study, ulna shortening osteotomy greater than 5 years prior to study, and consent to study participation. Patients were excluded if the cause of ulna impaction was due to a specific cause other than trauma (i.e., Madelung's deformity), surgery had been performed less than 5 years prior to the study, they were less than 18 years of age at the time of study, could not be contacted for follow-up evaluation, or declined participation in the study.

Between 1990 and 2006, 84 patients with a primary diagnosis of idiopathic or post-traumatic ulna impaction syndrome underwent ulnar shortening osteotomy at our two institutions. The diagnosis of ulnar impaction syndrome was made based on complaint of ulnar-sided wrist pain in combination with physical examination and radiographic evidence of ulnocarpal abutment. A total of 33 patients (18 female, 15 male) were consented for participation in the study. No patient who was contacted declined participation in the study. Of the 51 patients who were not included in this analysis, 50 were lost to follow-up after attempts to obtain phone contact were unsuccessful and one was excluded based on concomitant scapholunate advanced collapse requiring partial wrist arthrodesis at the time of ulna shortening. The mean age of participants at the time of surgery was 44 years (range, 16–66). The dominant hand was involved in 64% of cases (21/33) and 45% (15/33) had a history of prior wrist fracture. Thirteen patients underwent concomitant wrist arthroscopy based on results of preoperative MRI in 12 of 13 cases and surgeon discretion in the one. Of these 13 patients, four were patients with a diagnosis of post-traumatic ulna impaction syndrome. Two patients underwent another wrist procedure (carpal tunnel release and carpal tunnel release with radial corrective osteotomy) at the same as ulnar shortening osteotomy (Table 1).

The most common preoperative symptom was ulnar-sided wrist pain (30/33). Three patients reported their preoperative pain to be primarily located on the ulnar–dorsal side of the wrist. Work-up included a detailed history, physical examination, and neutral rotation frontal radiographs of

Table 1 Patient demographics and procedures

Age	44.6 years (16–66)	
Gender	Male	15
	Female	18
Dominant hand	Yes	21
	No	12
Prior fracture	Yes	15
	No	18
Concomitant wrist procedure	TFCC debridement	7
	Carpal tunnel release	2
	TFCC repair	1
	Radial osteotomy	1

the wrist in all cases. In 21 of 33 patients, preoperative magnetic resonance imaging was also obtained to evaluate for abnormalities. Diagnosis was made on the basis of review of the history, examination, and imaging. All patients failed a minimum 4–6 week course of nonoperative management including oral nonsteroidal anti-inflammatory medications, wrist immobilization, or other modalities (therapy, injections, etc.) as indicated on a case-by-case basis.

Surgery was performed by six surgeons at two institutions. The goal of shortening was to obtain a final ulnar variance between 0 and –1 mm. All but one osteotomy were performed in an oblique plane to the long axis of the ulna. Fixation was achieved using a Rayhack plate system (Wright Medical Technology, Arlington, TN, USA) in 29 cases and a 3.5 mm standard compression plate (Synthes, West Chester, PA, USA) in four cases. Postoperative management varied on a case-to-case basis, but included wrist immobilization for 1–2 weeks with subsequent conversion to removable wrist immobilizer for an additional 4–6 weeks.

Determination of ulnar variance was based on a neutral posteroanterior wrist radiograph using the perpendicular line technique (Fig. 1a, b) [7, 17]. All measurements were performed by one of two of the authors (DF or MC) who are both hand fellowship-trained hand surgeons. All follow-up was performed by contacting patients by telephone. All patients who were successfully contacted agreed to participation in either a telephone ($n=32$) or mailed survey interview ($n=1$). Mean follow-up was 10 years, 2 months (range, 5–20 years). Current patient satisfaction was assessed by using a 1–5 scale with five representing the highest satisfaction. Current pain level was assessed by telephone using a 0–10 scale with 10 representing the highest level of pain. Patient-rated function was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. Additionally, patients were asked of their current work status and if they would choose to undergo the same procedure again. Any reoperation, including for removal of hardware, was also noted. All data analysis was descriptive in nature.

Results

Patients were satisfied with ulnar shortening osteotomy. Eighty-eight percent (29/33) of the patients were either satisfied or very satisfied with their surgery. Ninety-one percent of patients (30/33) reported they would undergo the surgery

Fig. 1. **a** A preoperative radiograph demonstrating the method for determination of positive ulnar variance (+UV). **b** Postoperative radiograph demonstrating resultant negative ulnar variance (–UV).

again. Of the three patients who reported they would not undergo the same procedure again, two had a preoperative diagnosis of idiopathic ulnar impaction syndrome. Two of the three underwent subsequent removal of hardware and the third patient was treated conservatively for complex regional pain syndrome.

Mean postoperative pain rating was 1.5 ± 2.2 with 21 patients (64%) reporting no current pain. In all cases with pain at time of final follow-up, current pain was located on the ulnar side of the wrist. There was no difference in postoperative ulnar variance between the group with current pain and the group without current pain.

Upper limb function at final follow-up was within normal limits for the majority of the cohort [8]. Mean DASH score at final follow-up was 11 ± 12 . There was no difference in DASH score for patients with a preoperative history of wrist fracture compared to those without prior fracture (11 ± 12 for both). Two patients did not return to work following the procedure due to wrist pain or wrist function (2/33). These two patients were all laborers (steel worker and landscaper) and one of the two was over the age of 60 years at the time of surgery. Of the patients who were able to return to work ($n=31$), just one patient reported inability to return to preprocedure level of occupation as a construction worker.

All but four patients had films available for pre- and postoperative assessment of ulnar variance and plate position. These four cases were excluded for determination of mean ulnar variance, but included for analysis of subjective and functional results. The mean preoperative ulnar variance in our cohort was +3 mm (range, 0–10 mm). Mean shortening, as measured at surgery or on follow-up radiographic examination, was by 4 mm (range, 2.5–6.0 mm) for a postoperative mean ulnar variance of –1 mm (range, –5 to –3 mm).

Ten patients (30%) underwent removal of hardware. Plate removal did not seem to correlate with plate position or plate type (Table 2). One patient underwent a wrist arthroscopy for debridement of TFCC tear. One patient required reoperation for nonunion. Initial fixation had been performed with an oblique osteotomy fixed with a Rayhack plate. Of the shortening, 2.5 mm were performed with good compression and no patient-related risk factors for nonunion could be identified. The nonunion was treated with revision fixation using a 10-hole Synthes LC-DCP plate at 4 months following ulna shortening osteotomy. Local callus was used as bone graft and it went on to heal. Two patients underwent subsequent total wrist arthrodesis. Both of these patients had a preoperative diagnosis of post-traumatic ulna impaction syndrome. The rate of reoperation in our cohort of patients following ulna shortening osteotomy was 45%

Table 2 Plate removal according to plate position and plate type

		Number	Number removed (%)
Plate position	Ulnar	19	4 (21)
	Volar	6	3 (50)
	Dorsal	4	1 (25)
	Total	29 ^a	
Plate type	Rayhack	29	10 (34)
	Synthes	4	0 (0)
	Total	33	

^a Four cases are missing due to inability to determine plate position from medical and surgical records

(15 of 33; Table 3). The rate of reoperation did not differ in patients who had a history of wrist fracture when compared to patients who did not have a history of wrist fracture. One patient developed complex regional pain syndrome which was managed nonoperatively.

Discussion

Current literature lacks long-term outcomes following ulna shortening osteotomy. The purpose of this study was to report subjective satisfaction, pain relief, and upper limb function at a minimum of 5 years follow-up after ulna shortening osteotomy for ulnar impaction syndrome. We found that ulna shortening osteotomy provided good pain relief and patient satisfaction in midterm follow-up. Our cohort included patients with the diagnosis of post-traumatic as well as idiopathic ulnar impaction. These groups of patients have been studied independently in the past, but we found that mid-term outcomes are similar between the two groups. Our findings demonstrate that previously published short-term data suggesting good functional outcomes and satisfaction following ulna shortening osteotomy are maintained over longer follow-up [1, 4, 6, 12, 16].

There are several limitations to this study. First is the retrospective design. We do not present preoperative scores for comparison with postoperative DASH and pain scores. Additionally, as a telephone follow-up study, we do not have relevant physical examination findings to confirm the location of pain or to compare the operative wrist with the nonoperative side. Nonetheless, current estimates of satisfaction, pain, and function should provide a useful estimate of midterm outcomes following ulna shortening osteotomy. Finally, we were only able to reach 40% of patients who underwent the procedure, which introduces the possibility of sampling bias. In an attempt to maximize the number of

subjects enrolled, we have pooled the experience of two tertiary referral centers. Despite the limitations mentioned, the current study provides data on midterm subjective patient satisfaction, pain relief, and function following ulna shortening osteotomy. Our study suggests that previously published good short-term results are durable over time, but going forward, prospective studies are needed.

Fricker et al. followed 28 patients with post-traumatic ulnar impaction for an average of 20 months and found that 79% returned to their preoperative level of occupation [6]. Constantine et al. found that 82% (9 of 11) patients returned to previous level of employment [5]. In Fricker's cohort, 89% of patients reported they would have the same procedure again. At mean follow-up of 33 months, Loh reported mean improvement of pain on visual analog score from 6.3 (range, 3–10) preoperatively to 3.9 (range, 1–10) postoperatively [9]. Our results suggest that this high level of function, satisfaction, and pain relief is maintained over time. Despite good pain relief, 33% (11 of 33) of our patients reported mild ulnar-sided wrist pain at the time of final follow-up. Wrist arthroscopy is commonly performed at the time of ulnar shortening osteotomy due to TFCC pathology [16]. We found no difference in postoperative DASH score based on concomitant wrist arthroscopy. Plate irritation following ulnar shortening osteotomy is common. Removal of hardware was performed in 45% (5 of 11) patients in Constantine's cohort [5]. Loh et al. reported a plate removal in 7 of 23 (30.4%) with plate irritation in 65% [9]. They also reported two cases of complex regional pain syndrome and one case of nonunion (4%). Sammer and Rizzo similarly report the average rate of nonunion as 5% [16]. Nonunion occurred in one patient in our cohort of 34 (2.9%). All but one case in our cohort had an oblique osteotomy (including the case that went on to nonunion) and the majority underwent fixation with the Rayhack system. There have been reports suggesting these techniques decrease the rates of delayed and nonunion [3, 14]. Two of our patients required subsequent total wrist arthrodesis. Both patients had progressive radiocarpal arthritis relating to prior wrist fracture. For both patients, fusion occurred in the early to intermediate time period (<3 years). As such, we do not believe that fusion is an expected long-term outcome following ulna shortening osteotomy, but rather that these cases represent progression of co-existing post-traumatic arthritis.

A concern raised with ulna shortening osteotomy is the resultant increased pressure in the distal radioulnar joint that has been shown biomechanically [11, 13]. Nishiwaki et al. suggested that these pressure changes may lead to arthritic changes in the DRUJ with time [13]. While in our cohort, one third of patients reported some degree of ulnar-sided wrist pain at a mean 10 years follow-up, most patients were satisfied and reported they would undergo the same procedure again. Only one patient underwent a subsequent DRUJ procedure (wrist arthroscopy with TFCC debridement) and no patient required partial or complete ulnar resection or replacement. It is possible that asymptomatic DRUJ arthrosis exists in our patients as our study did not include repeat radiographic evaluation.

Ulna shortening osteotomy results in reliable midterm patient satisfaction, pain relief, and upper limb function for

Table 3 Secondary surgery

Type of surgery	Number
Removal of hardware	10
Wrist fusion	2
Wrist arthroscopy (TFCC debridement)	1
Revision for nonunion	1
Total	14

the treatment of both idiopathic and post-traumatic ulnar impaction syndrome. A high rate of hardware removal can be expected. In spite of this, the majority of patients maintain a high level of function, are able to return to preoperative level of employment, have low pain ratings, and have high satisfaction over longer-term follow-up than previously reported in the literature.

Disclosures

Conflict of Interest: Duretti T. Fufa, MD, Ryan P. Calfee, MD, Nandita Sriram, BS, Andrew J. Weiland, MD have declared that they have no conflict of interest. Richard H. Gelberman, MD is a board member of JBJS Board of Trustees and Healthpoint Capital and receives royalties from Wolters-Kluwer and Medartis, outside the work. Michele G. Carlson, MD is a board member of ASSH, received a RJOS Research Grant, payments for manuscript preparation from Hand Clinics Editor 2012, patent pending on a retractor, and payments for travel expenses for meetings from HSS and ASSH, outside the work.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the Responsible Committee on Human Experimentation (institutional and national) and with the Helsinki Declaration of 1975 as revised in 2008 (5).

Informed Consent: Informed consent was obtained from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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