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Long-term outcomes after ulna shortening osteotomy: a mean follow-up of six years

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Aims

The primary aim of this study was to describe long-term patient-reported outcomes after ulna shortening osteotomy for ulna impaction syndrome.

Methods

Overall, 89 patients treated between July 2011 and November 2017 who had previously taken part in a routine outcome evaluation up to 12 months postoperatively were sent an additional questionnaire in February 2021. The primary outcome was the Patient-Rated Wrist and Hand Evaluation (PRWHE) total score. Secondary outcomes included patient satisfaction with treatment results, complications, and subsequent treatment for ulnar-sided wrist pain. Linear mixed models were used to compare preoperative, 12 months, and late follow-up (ranging from four to nine years) PRWHE scores.

Results

Long-term outcomes were available in 66 patients (74%) after a mean follow-up of six years (SD 1). The mean PRWHE total score improved from 63 before surgery to 19 at late follow-up (difference in means (Δ) 44; 95% confidence interval (CI) 39 to 50; p = <0.001). Between 12 months and late follow-up, the PRWHE total score also improved (Δ 12; 95% CI 6 to 18; p = < 0.001). At late follow-up, 14/66 of patients (21%) reported a PRWHE total score of zero, whereas this was 3/51 patients (6%) at 12 months (p = 0.039). In all, 58/66 patients (88%) would undergo the same treatment again under similar circumstances. Subsequent treatment (total n = 66; surgical n = 57) for complications or recurrent symptoms were performed in 50/66 patients (76%). The most prevalent type of reoperation was hardware removal in 42/66 (64%), and nonunion occurred in 8/66 (12%).

Conclusion

Ulna shortening osteotomy improves patient-reported pain and function that seems to sustain at late follow-up. While satisfaction levels are generally high, reoperations such as hardware removal are common.

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Introduction

Ulna shortening osteotomy (USO) is an established treatment option for patients with ulnar impaction syndrome (UIS).[1-3] Previous studies reported good results, but mainly focused on radiological outcomes[4-7] or clinician-reported outcome measures.[4] However, these studies often lacked patient-reported outcome measures (PROMs), preoperative measurements,[5] or had a small sample size.[8-10]

Our previous study on 106 patients found beneficial outcomes in patient-reported pain and function 12 months after USO, measured with the Patient-Rated Wrist and Hand Evaluation (PRWHE).[11,12] While short-term outcomes are favourable, long-term PROMs beyond one year after USO are barely reported. However, we need to know whether short-term outcomes are sustainable at late follow-up as USO realigns the distal radioulnar joint (DRUJ) and changes the multidirectional status of the joint,[13] and

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multiple studies have reported osteoarthritic changes at long-term follow-up.[4,5,14,15] For example, De Runz et al[5] found that 63% of the patients had worsening or developing distal radioulnar joint osteoarthritis (DRUJ OA) at a mean follow-up of five years (1 to 10) after USO. As DRUJ OA can result in symptoms that might require subsequent treatment (such as DRUJ arthroplasty), it is crucial to know whether patients still benefit from USO after long-term follow-up or whether outcomes decline.

This follow-up study aimed to investigate the late postoperative patient-reported pain and functional status in patients undergoing ulna shortening osteotomy for ulna impaction syndrome using the PRWHE. Secondary outcomes included patient satisfaction with the treatment result, complications, and additional treatment for persistent/recurrent ulnar-sided wrist pain.

Methods

This was an observational prospective cohort study, reported according to the Strengthening the Reporting of Observational Studies in Epidemiology statement.[16] Data were collected at Xpert Clinics, a multicentre institution specializing in hand surgery and hand therapy in The Netherlands. The local Medical Research Ethical Committee approved the study (NL/sl/MEC-2019-0486). All patients provided written informed consent for their data to be anonymously used for this study.

Patients who underwent USO between July 2011 and February 2017 were contacted again for a late follow-up extension of our routine outcome measurement system.[17] After consultation with a hand surgeon, patients visiting our institution were invited to be part of a quality registry using GemsTracker (The Netherlands) electronic data capture tools. Upon agreement, they received secure web-based questionnaires before and at defined timepoints up to 12 months after treatment. Comprehensive details about the research setup, patient assessment, and follow-up regiment of the Hand and Wrist Cohort have been described previously.[17,18]

Participant selection. We identified 126 patients with a treatment code of USO in the Hand and Wrist cohort between July 2011 and February 2017 (minimally four years before initiating this study). We excluded three patients aged younger than 18 years and 17 patients who did not complete the PRWHE before surgery. We reviewed electronic patient records to confirm that the USO was performed for UIS, as USO may also be used for other indications. As in our previous study,[12] at least one of the following criteria needed to be met to be included in the study: 1) the surgeons explicitly diagnosed the patients with UIS in the electronic patient records; 2) wrist arthroscopy showed signs of type 2 lesions, such as triangular fibrocartilage complex (TFCC) degeneration and lunate chondropathy, according to Palmer;[19] 3) magnetic resonance imaging (MRI) showed signs of focal abnormal signal intensity in the lunate, triquetrum, and ulnar head;[20] and 4) there was evident static or dynamic ulnar positive variance on standard posterior-anterior wrist radiographs in a neutral position.[21] This definition excluded three patients that underwent USO for other indications. A total of 14 patients who underwent simultaneous ligament reconstruction for instability (extensor carpi ulnaris (ECU) loop, three-ligament tenodesis, and TFCC reinsertion) were also excluded. This left 89 patients contacted in February 2021 to fill in questionnaires on pain, hand function, satisfaction, and complications.

Surgical procedure. The USOs were performed by ten Federation of European Societies for Surgery of the Hand (FESSH)-certified hand surgeons with experience levels three (n = 4), four (n = 5), and five (n = 1).[22] Surgery was performed under general or regional anaesthesia. All USOs were performed at the level of the distal diaphysis using an oblique osteotomy that was made freehand or with an external cutting device based on surgical preference. The median amount of shortening was 4 mm (interquartile range (IQR) 3 to 4) and was based on preoperative ulnar variance. The ulna was fixed using a compression plate and screws (LCP/LC-DCP; Synthes, Switzerland) or an ulna specific system (Acumed, USA; Zimmer Biomet, The Netherlands; LCP Ulna Shortening System; Synthes).

Rehabilitation. The routine postoperative immobilization protocol has been described before.[12] The entire postoperative protocol is shown in Supplementary Material table i. Our hand surgery and therapy centre are fully integrated, and postoperative hand therapy was closely monitored. Standard radiographs were taken at three and 12 months postoperatively to assess bony union. Additional radiographs were made on indication (e.g. in case of delayed union, nonunion, or trauma). Hardware removal was considered when patients experienced irritation from the plate and when complete bone union was confirmed on the radiograph, which is considered a valid reason in The Netherlands.[23,24]

Variables and data sources/measurements. Age, sex, type of work, symptom duration, treatment side, hand dominance, and smoking status at the time of surgery were routinely registered. We reviewed the medical records to collect data on treatment of the initial injury, operative variables, and the occurrence of complications and subsequent treatment.

Patients were sent the Dutch-language version of the PRWHE to evaluate surgical outcomes.[11,25] The PRWHE is a validated questionnaire, and previous research found that it is a very responsive patient-derived questionnaire to evaluate the treatment outcomes of USO.[26–28] It consists of 15 questions relating to pain and function, with a total score ranging from zero (no pain or dysfunction) to 100 (maximum pain and dysfunction). The minimal clinically

important difference (MCID) in the PRWHE total score for patients who underwent USO for idiopathic UIS is 17.[26]

We used the satisfaction with treatment results questionnaire to assess patient satisfaction, which has good test-retest reliability and construct validity in patients with hand and wrist conditions.[29] Patients were asked to score how satisfied they were with the treatment outcome on a five-point Likert scale as "poor", "moderate", "fair", "good", and "excellent". Furthermore, patients were asked about their willingness to undergo treatment again: "yes" or "no".

Additionally, patients were asked if they had had a complication and whether they had undergone subsequent treatment for persisting/recurrent complaints (both "yes" or "no"). If patients answered with "yes", they were asked when and what kind of additional treatment ("painkillers", "hand therapy", "immobilization therapy", "surgery", or "other") they underwent.

Patients who did not respond to the questionnaires (non-responders) received two rounds of reminders with two weeks in between. After the two reminders, patients who did not complete the questionnaire were contacted by phone to request participation.

The primary outcome of this study was the improvement in PRWHE total score after a minimum of four years of follow-up. Secondary outcomes were the PRWHE subdomains pain and function (0 to 50), satisfaction with the treatment result, complications, and subsequent treatment.

Statistical analysis. The study size was determined by the number of patients treated within the study period that responded to all questionnaires. We performed a post hoc power analysis: with the sample size of 66 patients, we could detect a medium effect size (d) of 0.35, using an α error probability of 0.05 and power of 80%.[30] Continuous data were checked for normal distributions with histograms and quantile-quantile plots. Normally distributed data were displayed as mean values, including standard deviations (SDs) and skewed data with median values and inter-quartile ranges (IQRs). We compared demographic data and PRWHE scores between patients who completed the late follow-up assessment (responders) and patients who did not (non-responders) using independent-samples *t*-tests, Mann-Whitney U tests, and chi-squared tests. We used a linear mixed model (LMM) to compare the PRWHE total score between time points. We did not find any violation of the model assumptions: linearity, homoscedasticity, and normality of the residuals. Furthermore, we determined the percentage of patients who achieved the MCID of 17 between intake and 12 months, and late follow-up. A p-value < 0.05 was considered significant. All analyses were performed using R statistical software (R Project for Statistical Computing, Austria).

Table I. Characteristics of the study population at intake.

Variable	Data
Total, n	66
Mean age, yrs (SD)	46 (13)
Male sex, n (%)	21 (32)
Duration of symptoms, median (IQR)	14 (7 to 25)
Type of work, n (%)	
None	20 (30)
Light	11 (17)
Medium	19 (29)
Heavy	16 (24)
Dominant side affected, n (%)	34 (52)
Ulna shortening, mm, median (IQR)	4 (3 to 4)
Aetiology, n (%)	
Idiopathic	43 (65)
Acquired (distal radius fracture)	23 (35)
Technique, n (%)	
Freehand, fixed with LCP/LC-DCP	36 (55)
Ulna specific system	30 (45)
Manufacturer, n	
Acumed	26
Biomet	1
Synthes	3

IQR, interquartile range; LC-DCP, limited contact dynamic compression plate; LCP, locking compression plate; SD, standard deviation.

Results

Of the 89 patients who were contacted for this study, 66 patients (74%) completed the questionnaires, one patient (1%) had passed away due to an unrelated cause, and 22 patients (25%) could not be reached. No differences in demographic variables and PRWHE scores at intake or 12 months between responders and non-responders were observed (Supplementary Material table ii). A total of 66 patients were included; characteristics are displayed in Table I. The mean age was 46 years (SD 13; range 18 to 73), and 21/66 of patients (32%) were males. The USO was performed freehand in 36/66 (55%) and using an ulna specific system in 30/66 (45%). The mean late follow-up after surgery was 6.3 years (standard deviation (SD) 1.3; min 4.0; max 9.0). PRWHE scores were available for all 66 patients before surgery and at late follow-up, while 51 patients also provided PRWHE scores after 12 months.

Patient-reported pain and hand function. To justify pooling late follow-up PRWHE scores as one timepoint in patients with variable follow-up (four to nine years), mean scores were compared between patients with a follow-up between four to six years (n = 33) and patients with a follow-up between six to nine years (n = 33). No difference was found between the two groups (18; 95% confidence interval (CI) 11 to 25 vs 19; 95% CI 13 to 26; p = 0.775, linear mixed model), suggesting that pooling was justified.

The mean PRWHE total score improved from 63 before surgery to 19 at late follow-up (difference in means (Δ) 44;

Table II. Mean Patient-Rated Wrist and Hand Evaluation (PRWHE) scores before surgery, at 12 months, and late follow-up (mean of six years) after ulna shortening osteotomy.

Category	Baseline (95% CI)	12 mnths (95% CI)	6 yrs (95% CI)	Before 6 yrs† (95% CI)	1 to 6 yrs† (95% CI)
Patients, n	66	52	66		
PRWHE total score	63 (58 to 68)	31 (25 to 37)	19 (14 to 24)	44 (39 to 50)*	12 (6 to 18)*
PRWHE pain score	33 (30 to 36)	17 (14 to 20)	11 (8 to 14])	22 (19 to 25)*	6 (3 to 9)*
PRWHE function score	30 (27 to 33)	13 (11 to 16)	7 (5 to 10)	22 (20 to 25)*	6 (3 to 9)*

*p < 0.001, pairwise testing from the linear mixed model.
†Difference between the defined time points.
CI, confidence interval.

95% CI 39 to 50; p < 0.001, linear mixed model; Table II). Between 12 months and late follow-up, the PRWHE total score also improved (Δ 12; 95% CI 6 to 18; p < 0.001, linear mixed model). Pain and function subscales showed similar improvement (Table II). At late follow-up, 14/66 patients (21%) reported a PRWHE total score of zero, whereas this was 3/51 (6%) at 12 months (p = 0.039, two proportion Z-test).

Figure 1 shows a large variation between the individual longitudinal PRWHE scores. Overall, 56/66 of the patients (85%) improved beyond the MCID (17) at late follow-up, whereas this was 73% (37/51) at 12 months (p = 0.161, two proportion Z-test). One patient who decreased beyond the MCID between intake and 12 months (29 points) underwent hardware removal as subsequent treatment and improved at late follow-up (32 points). Between 12 months and late follow-up,16/51 (31%) improved, 2/51 (4%) became worse, and 33/51 (65%) showed no change in relation to the MCID range. Overall, 20 patients already had a PRWHE score ≤ 17 at 12 months and could not improve beyond the MCID.

Satisfaction with treatment. At late follow-up, 28/66 patients (42%) rated their satisfaction with treatment outcome as excellent, 24/66 (36%) as good, 10/66 (15%) as fair, 3/66 (5%) as moderate, and 0/66 (0%) as poor, and one patient (1%) did not respond. A total of 58/66 patients (88%) would undergo the same treatment again under similar circumstances, 7/66 (11%) would not, and one patient (1%) did not respond. The reasons for the seven patients that would not undergo USO again were a time-consuming rehabilitation period (n = 4), high levels of acute postoperative pain (n = 2), and persistent ulnar sided wrist pain (n = 1). The two patients who had worse PRWHE scores late follow-up compared to their 12-month measurement rated their satisfaction as excellent and fair, and both would undergo USO again.

Complications and additional treatments. A total of 13/66 patients (20%) reported having undergone subsequent therapy for a complication or persisting/recurrent ulnar-sided wrist pain. This was lower than the rate of subsequent therapy recorded in the patients' charts (50/66 (76%); p < 0.001, two proportion Z-test). The specific patient-reported and clinician-reported subsequent therapies are displayed in Table III. The most common type of subsequent surgical treatment was hardware removal (42/66 (64%)). Hardware removal was performed after a median of 11.2 months (IQR 7.5 to 13.4) since USA. In all, 8/66 of patients (12%) had a nonunion: five patients after a freehand USO and three with an ulna specific system. Revision surgery was performed after a median of 5.4 months (IQR 4.6 to 6.7) since USO and bone union was subsequently achieved in all patients. Posthoc analyses showed that patients who had experienced a nonunion had a worse PRWHE score than the other patients at 12 months (Δ -20; 95% CI -37 to 2; p = 0.029, linear mixed model), but a similar score at late follow-up (Δ -8; 95% CI -24 to 8; p = 0.327, linear mixed model) (Table IV).

Discussion

We found beneficial long-term patient-reported outcomes after USO in patients treated for ulna impaction syndrome. While most improvement was observed in the first 12 months, mean PRWHE scores improved further between 12 months and late follow-up. After a mean of six years, 85% of the patients had improved beyond the MCID, and 21% reported the best possible PRWHE score (score of zero). In all, 78% of the patients rated their satisfaction with treatment results as good or excellent, and 88% would undergo the same treatment again. Furthermore, 64% of the patients required reoperation for hardware removal.

In a previous study with a mean follow-up of five years after USO, 63% of the patients had developed or worsened DRUJ OA.[5] Therefore, the question raised whether long-term patient-reported outcomes still were favourable. Only limited long-term PROM data using the PRWHE after USO are available. We found a mean improvement of 44 points on a zero to 100 scale between preoperative and late-term patient-reported pain and hand function. Hassan et al[8] reported similar results in 20 patients with previous distal radius fractures who had an improvement of 53 points on the PRWHE after a mean follow-up of 24 months. Our mean late-follow up PRWHE score (mean = 19) is comparable to results from Roulet et al,[7] who reported a mean PRWHE score of 22 points in 25 patients after a mean follow-up of 5.3 years, and seems better than the study from de Runz et al,[5] who reported a mean score of 33 in 46 patients after a mean follow-up of 5.2 years.

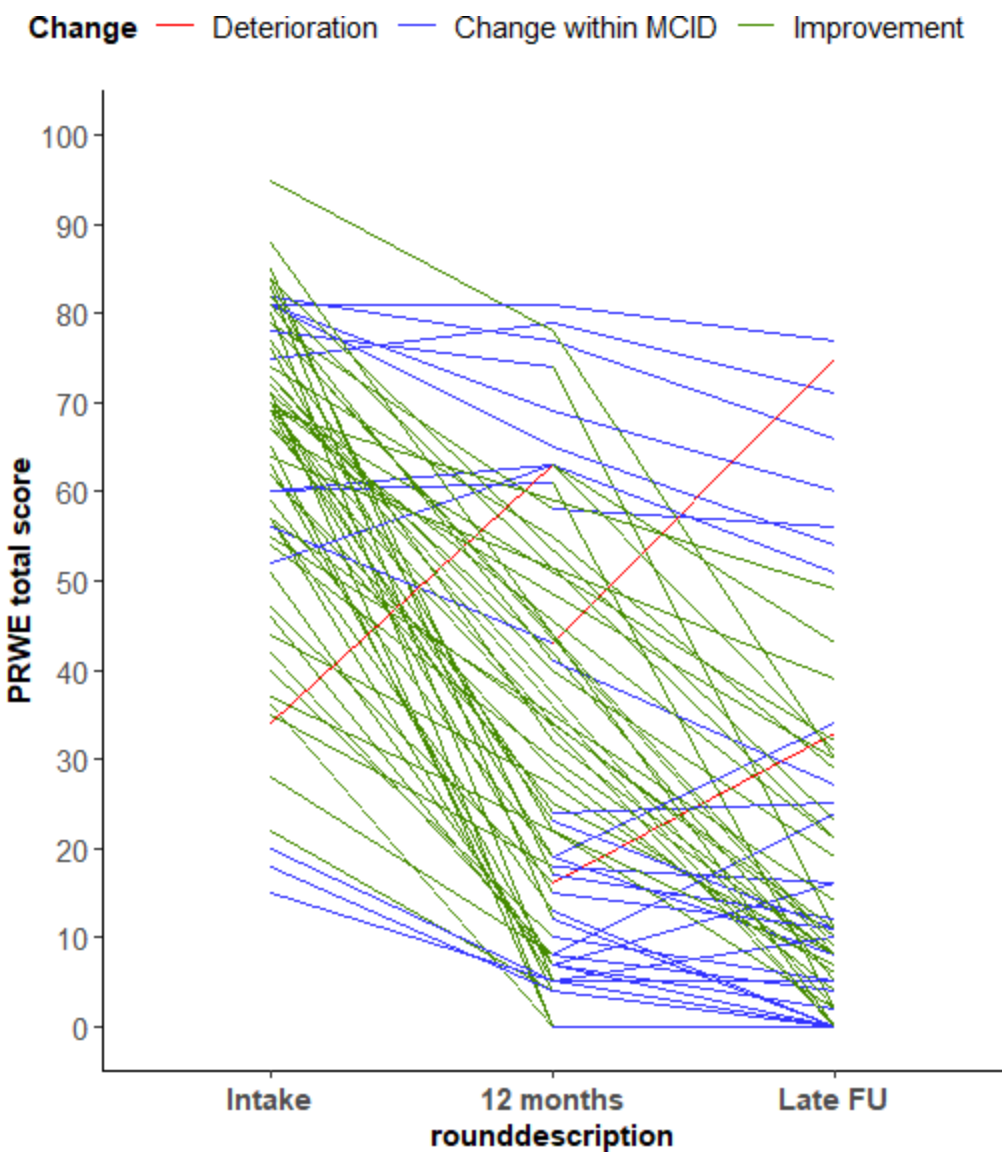

Fig. 1

Longitudinal individual Patient-Rated Wrist and Hand Evaluation (PRWHE; range 0 to 100) total score before surgery and at 12 months and late follow-up (mean of six years) after surgery. Individual lines were code coloured between timepoints (intake to 12 months; 12 months to late follow-up; intake to late follow-up if the 12-month score was missing) based on their change score in relation to the minimal clinically important difference of 17 points.

In addition to showing that long-term outcomes were similar to previous reports, our study also revealed no signs of functional deterioration at long-term follow-up compared to short-term outcomes.

Despite the observed improvement after USO, the mean long-term PRWHE score (mean = 19) still was worse than the age-standardized reference ranges from the general Dutch population (mean = 8).[31] This finding was also observed after a late follow-up of patients who underwent corrective osteotomy of the distal radius[32] or patients who underwent open repair of the triangular fibrocartilage complex (TFCC).[33] These data may be important for managing treatment expectations.

We observed a considerable variation in pain and hand function scores between patients at all timepoints. While a mean improvement of 44 points was observed, the improvement in PRWHE scores ranged from three to 88 points. Furthermore, one patient deteriorated with 19 points compared to preoperative scores. The reason for this variation is still largely unknown. De Runz et al[5] found that patients with DRUJ osteoarthritis had worse PRWHE scores than patients without,[5] and other studies suggested that the DRUJ morphology affected the outcome.[4,6,7] However, this study did not have radiological data at late follow-up, and DRUJ morphology could not reliably be assessed. Future prospective studies

Table III. Subsequent treatment reported by the patient and clinician after ulna shortening osteotomy in 66 patients after late follow-up (mean of six years). Only the most invasive (surgical treatment) was registered if multiple treatments were required for the same indication.

Treatment (explanation)	Patient-reported, n	Clinician-reported, n
Subsequent treatment, patients	13	50
Non-surgical treatment		
Painkillers	0	0
Antibiotics	0	0
Cortico steroid injection (ECU tendintis)	0	3
Hand therapy (improve ROM)	3	4
Splinting	0	0
Bone stimulation (ulna fracture after hardware removal)	1	1
Pain clinic	1	1
Surgical treatment		
Revision (nonunion)	4	8
Revision (additional shortening)	0	1
Hardware removal (hardware irritation)	4	42
TFCC reinsertion, dorsal capsulodesis (DRUJ instability)	2	2
PIN neurectomy	1	1
Pisiformectomy	0	2
Cubital tunnel release	0	1

DRUJ, distal radioulnar joint; ECU, extensor carpi ulnaris; PIN, posterior interosseus nerve; ROM, range of motion; TFCC, triangular fibrocartilage complex.

Table IV. Posthoc comparison of the mean Patient-Rated Wrist and Hand Evaluation total score at 12 months and late follow-up (mean of six years) after ulna shortening osteotomy between patients with (n = 58) and without a nonunion (n = 8).

Timepoint	Nonunion = no, n (mean; 95% CI)	Nonunion = yes, n (mean; 95% CI)	Between groups, mean (95% CI)*	p-value†
Baseline	58 (63; 57 to 68)	8 (65; 50 to 80)	-2 (-18 to 14)	0.792
12 months	46 (28; 22 to 35)	6 (48; 32 to 65)	-20 (-37 to 2)	0.029
6 yrs	58 (18; 12 to 23)	8 (26; 11 to 41)	-8 (-24 to 8)	0.327

*Difference between the defined time points.
†Pairwise testing from the linear mixed model. An interaction term between time and group was included in the model to test for differences over time.
CI, confidence interval.

should further investigate predictors for the long-term patient-reported outcome after USO.

The difference in the rate of patient-reported and clinician-reported subsequent treatments for complications and persisting symptoms is interesting. This is in line with a previous study from our group on the long-term outcomes of open TFCC repair.[33] Even some of the more severe complications, such as nonunion, were not reported by some patients. We hypothesize that this may be due to adequate treatment of the complication. High rates of reoperations after USO have been described before.[34,35] The most common cause of reoperation after USO seems to be hardware removal.[35,36] In our institution, indications for hardware removal are mainly based on patient complaints such as pain and tenderness over the plate, impaired range of motion (ROM), paresthesia and cold intolerance. Some authors advocate that appropriate plate placement might avoid these symptoms and reduce hardware removal,[36–39] but there is no consensus on the best placement location yet. While the plate was removed in 42 patients, only four patients considered this a complication. This might be due to the adequate preoperative consultation in which patients were informed that reoperation to remove hardware removal was likely to occur. The nonunion rate in our study sample was relatively high compared to our previous study (12% vs 6%) and the pooled estimate from the meta-analysis by Owens et al[40] (4%).[12] We could not find the cause for a higher incidence in our study as multiple prognostic factors for nonunion after USO, such as bone density and ROM, were not measured.[41] We observed that patients who experienced a nonunion (subsequently treated) had an impaired functional outcome at 12 months, but this difference disappeared at late follow-up. Next to hardware removal and nonunion, other subsequent procedures were performed for persistent/recurrent ulnar-sided wrist pain in some patients. This observation is also noted in other studies addressing surgical outcomes of ulnar-sided wrist pain[33,35,42] and may result from coexisting pathology.[43] In our study, none of the patients underwent DRUJ arthroplasty for DRUJ OA. Future studies are needed to validate these results and investigate conversion rates after longer follow-up durations.

We have not been able to find other studies evaluating patient satisfaction after USO using the validated satisfaction with treatment results questionnaire. Stockton et

al[1] performed a meta-analysis pooling different scoring systems for patient satisfaction and showed that 76% had a "good" to "excellent" outcome. This is similar to our findings. Feitz et al[33] used the same questionnaire to evaluate long-term patient satisfaction after open TFCC repair, and found similar rates of patients with an excellent outcome (42% vs 40%) and patients who would undergo the same treatment again (88% vs 87%).

This study has strengths and limitations. Strengths include the data collection using standardized PROMs, which occurred prospectively in daily practice. The availability of preoperative PRWHE scores enabled us to quantify the improvement in pain and hand function. Also, these outcomes reflect the results of multiple surgeons, again increasing the validity. A limitation of our study is the number of patients lost to follow-up (25%), making our results less generalizable to the entire patient cohort. However, the results from our responder analyses indicated that PRWHE scores between responders and non-responders before surgery and 12 months after surgery did not differ. Second, the inclusion of both freehand USOs and osteotomy-guided USOs may be considered a limitation. One could argue, however, that our study results are more generalizable. Third, we did not have long-term radiological and clinician-reported outcomes, such as DRUJ status. grip strength, and ROM. While validated PROMs (such as the PRWHE) are recognized to assess functional outcomes, future studies should investigate long-term radiological follow-up and relate these findings to PROMs and functional outcomes.

Take home message

- The improvement in patient-reported outcomes after ulna shortening osteotomy is sustainable at long-term follow-up.

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Supplementary material

Tables showing postoperative therapeutic regime after ulna shortening osteotomy; and demographics and Patient-Rated Wrist and Hand Evaluation scores between responders and non-responders.

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