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Research Paper: Corrective Osteotomy With K-Wire Fixation For the Treatment of Symptomatic Distal Radius Extra-Articular Malunion

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ABSTRACT

Background: Optimization of the corrective osteotomy for treating distal radius extra-articular malunion is an ongoing project.

Objectives: In this study, we aimed to evaluate the outcome of corrective osteotomy with K-wire fixation in treating patients with symptomatic distal radius extra-articular malunion.

Methods: Twenty-three patients with symptomatic extra-articular malunion of the distal radius, with a Mean±SD age of 38.3±7.6 years, and a Mean±SD follow-up of 34.4±11.3 months were enrolled in this study. Corrective osteotomy was performed through a dorsal approach and using K-wire instead of the plate for the fixation of the osteotomy site. The outcome was assessed with radiographic measurements of ulnar variance, radial tilt, radial inclination angle, radial height, and clinical assessment of wrist range of motion, the short form of Disabilities of the Arm, Shoulder, and Hand (Quick-DASH), and the Modified Mayo Wrist Score (MMWS).

Results: Radiographic measurements and wrist range of motion in all directions were significantly improved at the last follow-up. The Mean±SD final Quick-DASH score of the patients was 16.3±8. The Mean±SD final MMWS was 92.2±13.5. According to the MMWS, 9 patients (39.1%) had an excellent function, 13 (56.5%) had a good function, and one (4.4%) had a fair function. Radiographic union was observed in all wrists within an Mean±SD period of 10.2±4 weeks. No postoperative complication was recorded.

Conclusion: Since K-wire fixation is less expensive, requires a smaller incision, and provides acceptable radiologic and clinical outcomes, it could be a good alternative for plate fixation in corrective osteotomy for distal radius extra-articular malunion.

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1. Introduction

Malunion is a common complication following the distal radius fracture, with a maximum incidence of 17% [1]. It can occur after initial surgical and nonsurgical treatment. However, the risk of malunion is higher if the patient is initially treated non-surgically [1-3]. It is associated with significant disability and increases the risk of both radiocarpal and distal radioulnar joint arthrosis [4].

The treatment aims to restore the original anatomy of the distal radius adequately. Corrective osteotomy is the most frequently used procedure for treating symptomatic malunion following the distal radius fracture. Although it significantly improves wrist and forearm motion, pain, and grip strength, it is also a challenging procedure with unpredictable clinical outcomes [5]. Therefore, optimizing the corrective osteotomy to treat distal radius malunion is an ongoing project [6].

In the conventional corrective osteotomy procedure, the osteotomy site is fixed with a volar or dorsal plate [7]. We hypothesized that fixation of the osteotomy site with Kirschner wires (K-wires) could be a less invasive approach by making a smaller incision. It is also less expensive than plate fixation, does not require a plate removal surgery, and does not cause tendon irritation by the protrusion of the screw heads from the cortex [8].

Also, it lacks plate-associated complications such as plate breakage [9]. Therefore, if the outcome of corrective osteotomy with K-wire is comparable with plate fixation, it could be a suitable alternative for plate fixation, particularly in developing countries where surgical expenses are a matter of concern.

Objectives

In this study, we aimed to evaluate the outcome of corrective osteotomy with K-wire fixation in treating patients with symptomatic distal radius malunion.

2. Methods

This retrospective cohort study was approved by the Review Board of our institute. We reviewed the patients' medical profiles referred to our tertiary orthopedic hospital between 2015 and 2019 who had a radiographic diagnosis of distal radius malunion. The patients were included in the study if they had pain, limited Range of Motion (ROM), limited grip strength, the dorsal tilt of a distal radius >15º, ulnar variance <20 mm, or severe deformity of the wrist caused by distal radius malunion. Patients were excluded if they had apparent intra-articular malunion in preoperative radiography (joint line step >2 mm), presence of symptoms showing the median nerve compression requiring release, congenital deformity in the upper limb, history of cerebral palsy in the upper extremity, history of diabetes mellitus and other metabolic disorders, and history of active smoking. Patients with a follow-up of less than one year were also excluded from the study. Finally, 23 patients were identified as eligible to be included in the study. Table 1 presents the patients' characteristics.

Surgical procedure

Under general anesthesia, inflamed tourniquet, and fluoroscopic control, we performed a dorsal approach to the distal radius with a 5- to 7-cm incision. The approach continued through the third and fourth extensor compartments, with the extensor tendons of the fingers left on the ulnar side and the extensor pollicis longus on the radial side. Then, under C-arm control, a guide pin was inserted along the joint surface, while another pin was

Table 1. Characteristic of the patients with distal radius malunion

Variables		Patients (n=23)
Age, Mean±SD (y)		38.3±7.6
Gender, No.(%)	Male	15 (65.5)
	Female	8 (34.5)
Hand dominancy, No. (%)	Dominant	13 (56.5)
	Non-dominant	10 (43.5)
Follow-up, Mean±SD (mo)		34.4±11.3

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Figure 1. (a & b) Anteroposterior and lateral radiographs of a distal radius malunion; (c & d) Anteroposterior and lateral radiographs of the same patients after corrective osteotomy and fixation with K-wires; (e & f) Anteroposterior and lateral radiographs of the same patients after pin removal

inserted in the location of malunion, parallel to the joint surface. Osteotomy of the malunion site was performed along with the guide pin according to the preoperative radiographic planning. The correction level was checked using intraoperative fluoroscopy and augmented with corticocancellous autograft obtained from the iliac crest. Afterward, the osteotomized bone fragments were fixed from distal to proximal using 3-4 K-wire (1.5 mm) (Figure 1). The pinheads were bent and gathered under the tendons so as not to obstruct the movement of the tendons. Finally, the correction level was re-evaluated under coronal and sagittal fluoroscopy. Rotations were checked to detect any general instability. If not present, the skin was sutured, and a volar palm splint was applied in functional mode.

Active finger ROM was started the day after the surgery. The first visit of the patients was two weeks after the surgery. In this visit, the wounds were checked, stitches were removed, and a short plaster cast was appropriately placed for 4 weeks. After performing a radiographic evaluation, the cast was removed, and active wrist ROM was started. After observing the clinical and radiologic union and at least six months past the surgery date, pins were extracted in the operative room and under sedation with a 2- to 3-cm incision.

Outcome measures

The outcomes of the patients were assessed radiographically and clinically. Radiographic measurements included ulnar variance, radial tilt, radial inclination angle, and radial height that were evaluated before the surgery and at the final follow-up. Clinical evaluation of the outcomes was performed both objectively and subjectively. Objective clinical outcomes were assessed before the surgery and at the last follow-up. These included wrist flexion, extension, supination, pronation, radial deviation, and ulnar deviation. Subjective assessment of clinical outcomes was only evaluated at the last follow-up. They included using the short form of Disabilities of the Arm, Shoulder, and Hand (Quick-DASH) [10] and the Modified Mayo Wrist Score (MMWS) [11]. Quick-DASH scores ranged from 0-100, and lower scores indicate a lower level of disability. The MMWS also ranged from 0-100, and a higher score indicates better wrist function. According to the MMWS, the wrist function is categorized as excellent (91-100 points), good (81-90 points), fair (71-80 points), and poor (<70 points).

Statistical analysis

Statistical analysis was performed using SPSS v. 16. The descriptive data were presented by Mean±SD or number and percentage. The Shapiro-Wilk test was used to evaluate the data with normal distribution. A paired t test or its nonparametric counterpart (Wilcoxon signed-rank test) was used to compare before and after the procedure. P values of less than 0.05 were considered significant.

3. Results

The Mean±SD ulnar variance was 14.8±8.6 mm before the surgery and 1.3±1.4 mm at the last follow-up (P<0.001). The radius was tilted dorsally before the surgery with a Mean±SD angle of 28.3±9.2º and turned into a volar angle of 4.4±3.1º at the last follow-up (P<0.001). The Mean±SD radial inclination angle was 18.3±7.6º before the surgery and 22.6±6.5º at the last follow-up (P=0.02). The Mean±SD radial height was 6.5±3.8 mm before the surgery and 14.5±7.4 mm at the last follow-up (P=0.001).

The Mean±SD wrist flexion was 44.4±10.6º before the surgery and 56.3±8.9º at the last follow-up (P=0.002). The Mean±SD wrist extension was 55.1±12.3º before the surgery and 60.3±11.8º at the last follow-up (P=0.005). The Mean±SD wrist supination was 52.3±11.7º before the surgery and 72.8±13º at the last follow-up (P<0.001). The Mean±SD wrist pronation was 65.6±14.2º before the surgery and 74.9±11.1º at the last follow-up (P=0.003). The Mean±SD radial deviation was 8.8±3.9º before the surgery and 13.9±5.2º at the last follow-up (P=0.01). The Mean±SD ulnar deviation was 17.8±6.3º before the surgery and 23.3±7.2º at the last follow-up (P=0.01). Table 2 presents the radiographic measurements and objective clinical assessments.

The Mean±SD Quick-DASH score of the patients was 16.3±8 (range 11-29) at the last follow-up, and the Mean±SD MMWS was 92.2±13.5 (range 70-100). According to the MMWS, 9 patients (39.1%) had an excellent function, 13 (56.5%) had a good function, and one (4.4%) had a fair function.

Radiographic union was observed in all wrists within an average±SD period of 10.2±4 weeks (range 8-12) after the surgery. No postoperative complications such as infection and wound complications were recorded in this series.

Table 2. Radiographic and objective clinical measurements of the patients before the surgery and at the last follow-up

Variables	Mean±SD		P
	Preoperative	Postoperative	
Ulnar variance (mm)	14.8±8.6	1.3±1.4	<0.001
Radial tilt (º)	28.3±9.2 (dorsal)	4.4±3.1 (volar)	<0.001
Radial inclination angle (º)	18.3±7.6	22.6±6.5	0.02
Radial height (mm)	6.5±3.8	14.5±7.4	0.001
Wrist flexion (º)	44.4±10.6	56.3±8.9	0.002
Wrist extension (º)	55.1±12.3	60.3±11.8	0.005
Wrist supination (º)	52.3±11.7	72.8±13	<0.001
Wrist pronation (º)	65.6±14.2	74.9±11.1	0.003
Radial deviation (º)	8.8±3.9	13.9±5.2	0.01
Ulnar deviation (º)	17.8±6.3	23.3±7.2	0.01

4. Discussion

In this study, we evaluated the outcome of K-wire fixation in corrective osteotomy for distal radius malunion. According to our results, radiographic measures of the outcomes were all significantly improved. The objective and subjective measures of outcomes were significantly improved, as well. Union of osteotomy site was observed in all patients. No postoperative complication was recorded.

Lozano-Calderón et al. evaluated the long-term outcomes of corrective osteotomy with plate fixation to treat 22 patients with distal radius malunion. Their mean follow-up of the patients was 13 years. The wrist flexion-extension and grip strength of the involved wrist averaged 72.5% and 71% on the contralateral wrist. The mean DASH score was 16. Results were categorized as fair on both the Gartland and Werley scores and the modified Green and O'Brien scores. Thirteen patients developed mild to moderate symptomatic wrist arthritis [12]. The mean DASH score of the patients was 16.3 in the present series that was comparable with the study of Lozano-Calderón. The follow-up period of the present study was not long enough to evaluate the incidence of wrist arthritis occurrence.

Andreasson et al. reported the outcome of corrective osteotomy fixated with a volar plate in treating 37 patients with malunited fractures of the distal radius 3-10 years after the surgery. The median Patient-Rated Wrist Evaluation (PRWE) score was 12. Mean grip strength was 89% of the uninjured side. All patients experienced some degree of pain after the surgery. They suggested corrective osteotomy for patients with a poor functional outcome after a distal radius fracture [13]. According to the patients' report, none of the patients had experienced pain until the last follow-up.

Stirling et al. reported patient-rated outcomes after corrective osteotomy with either a dorsal or a volar locking plate for 89 patients with symptomatic malunion of the distal radius. At a mean follow-up of six years, the median PRWE score was 22, the median QuickDASH score was 11.4, and the median EQ-5D-5L score was 0.84. They concluded that corrective osteotomy for distal radius malunion provides good functional outcomes. In addition, it is associated with high levels of patient satisfaction [14]. Similarly, good to excellent functional outcomes were observed in 95.6% of patients of the current study.

Opel et al. reported the outcome of corrective osteotomy for distal radius malunion using a fixed-angle volar locking plate. Twenty patients with a mean follow-up of 14 months were included in this study. Radiographic union was confirmed in all patients at an average of 3 months. No postoperative complication was recorded. The average postoperative DASH score was 13.48. Improvement of the wrist movements, ulnar variance, radial inclination, radial tilt, and supination was significant [15]. In the present study, the radiographic union was obtained in all patients within a mean period of 2.5 months. Similar to the study of Opel et al., radiographic measures

and wrist motion were significantly improved. No postoperative complication was recorded. The mean DASH score was also comparable with the study of Opel et al.

The outcome of corrective osteotomy for distal radius malunion has also been reported in several other studies [16-21]. Although the outcome of osteotomy is affected by several factors, such as the timing of osteotomy, the level of deformity, and the technical differences like the use of three-dimensional computer-assisted techniques [22], an acceptable outcome has been reported in the majority of studies. According to our results, using K-wire for the fixation of osteotomy provides comparable results with plate fixation.

The present study had some limitations. It was a retrospective study with a small number of patients. We did not evaluate the grip and pinch strength of the involved hand. In addition, subjective clinical assessments of outcomes were not recorded before the surgery, and the improvement level could not be estimated. Therefore, future complementary studies are required to confirm the results of this study.

5. Conclusions

Corrective osteotomy of distal radius malunion with K-wire fixation provides comparable radiologic and clinical outcomes with plate fixation. It is associated with a small risk of postoperative complications such as nonunion. Considering its lower costs and smaller incision size, it is a good alternative for plate fixation, particularly in developing countries demanding more affordable surgical procedures.

Ethical Considerations

Compliance with ethical guidelines

This retrospective cohort study was approved by the Review Board of our institute.

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Authors' contributions

Study conception and design: Hooman Shariatzade and Farid Najd Mazhar; Drafting manuscript: Mohsen Barkam; Data collection: Ali Dehghan, Mohammadreza Heidarikhoo, and Abbas Esmaeli; Reviewing the manuscript critically: Mazyar Rajei.

Conflict of interest

The authors have no conflict of interest to disclose.

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