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ORIGINAL ARTICLE

Distraction Osteogenesis for the Surgical Treatment of Malunited Distal Radius Fracture

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Background Malunion of fracture distal radius can cause pain and functional impact. Numerous surgical techniques have been implemented. Distraction osteogenesis allows gradual deformity correction and avoids bone grafting complications. This retrospective study aims to assess the results of distraction osteogenesis for the treatment of malunited distal radius fractures.

Patients and Methods Between February 2019 and March 2023, 12 patients (eight males and four females) with malunited distal radius fractures were managed with an Ilizarov external fixator. The corticotomy was done through a small dorsal incision. The lengthening was started 10 days postoperatively at a rate of 0.25mm every 6h until the deformity was corrected.

Results The average age of the patients was 30±2.5 years. The average follow-up time was 25.2±11 months. After an average of 2.5±0.6 months, the external fixator was removed. The average radius shortening was 9±4.150mm with an average lengthening of 12±2.189mm. A preoperative average of +3.7mm ulnar variance decreased to +0.62mm at the final follow-up with a statistically significant difference (P=0.017). Angular deformity improved from a preoperative average of 28±2.457º dorsal tilt to an average of 5±2.538º palmar tilt at the final follow-up with a statistically significant difference (P=0.01). A preoperative average of 12±6.150º radial inclination improved to 20±9.189º at the final follow-up with a statistically significant difference (P=0.01). One patient was complicated with Sudeck's atrophy. Statistically significant differences could be found as regards pain, grip strength, active range of motion of the affected wrist, mean Disabilities of the Arm, Shoulder and Hand score, and mean modified Mayo Wrist Score between the preoperative measurements and at the final follow-up (P=0.01, 0.012, 0.027, 0.014, and 0.001, respectively).

Conclusions Distraction osteogenesis with Ilizarov is a safe and effective procedure for the treatment of malunited distal radius fractures. It could correct the deformity and establish good functional results.

Keywords Distal radius, Distraction osteogenesis, Malunion.
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INTRODUCTION

When treating a distal end radius fracture conservatively, attention should be paid to an acceptable reduction according to the criteria of acceptance in the literature [1]. Malunion remains a common complication after conservative management of unstable extra-articular fractures [2]. Surgical indications for the treatment of malaligned distal radius are pain, loss of function, and unaccepted radial malalignment [3].

The goals of the treatment are to restore congruity of both distal radioulnar and radiocarpal joints, improve pain and function, reestablish normal carpal kinematics, and prevent future arthritis [4]. Operative techniques for the management of malunited fracture distal radius include osteotomy and fixation by cast, osteotomy, and fixation by K-wires, and osteotomy with or without bone graft supplemented with plate fixation [5].

However, when plates and screws are used, a high rate of plate removal has been reported due to painful hardware and tendons irritation [6]. Surgical techniques used in bone grafting may be complicated with donor site morbidity, especially pain, superficial sensory nerve injury, hematoma, and infection [7].

Many authors used a joint bridging fixator to provide rigid fixation. This technique has increased the rate of joint stiffness [8].

Based on the principles of distraction osteogenesis, which allows gradual deformity correction and avoids the complications of bone grafting, our aim for this retrospective study is to present the results of distraction osteogenesis for the treatment of malunited distal radius fractures.

PATIENTS AND METHODS

Between February 2019 and March 2023, 12 patients with malunited fracture distal radius were surgically treated with an Ilizarov external fixator based on the principles of distraction osteogenesis. The study was conducted at the Orthopedic Department, Mansoura University Hospital, after approval by the institutional research board. Informed consent was obtained from all studied patients.

Inclusion criteria included a malunion of distal radius fracture after conservative treatment in symptomatic patients with wrist pain, functional limitations, and disruption of the distal radioulnar joint. Exclusion criteria included patients with asymptomatic malunion with posttraumatic or degenerative joint changes. Also, patients with intraarticular malunion, pathological fractures, and extensive osteoporosis were excluded.

Before surgery, all patients were examined clinically by history taking and paying attention to sex, age, and complaints. Pain was assessed via the visual analog scale [9]. Also, all patients underwent a complete local examination of the affected side. Hand grip strength was measured with a dynamometer, and active range of motion of the affected wrist was evaluated (wrist flexion/extension and forearm pronation/supination). Anteroposterior and lateral radiographs of the affected wrist were taken, and the following measurements were carried out: palmar tilt, radial inclination, radial length, and ulnar variance. All patients underwent functional evaluation using the Disabilities of the Arm, Shoulder and Hand (DASH) score and the modified Mayo Wrist Score (MMWS) [10,11].

A pre-assembled Ilizarov circular external fixator with two half rings (with two/three pins on the proximal ring and two Ilizarov wires and one pin on the distal ring) was used for fixation after corticotomy of the distal radius. The corticotomy was done through a small dorsal incision under an image intensifier after the determination of its site.

All patients were discharged the next day. They were instructed about pin site care and distraction mechanisms. The lengthening was started ten days postoperatively at a rate of 0.25mm every 6h until the deformity was corrected. All patients were followed up every 2 weeks during this phase and then every month till the removal of the external fixator. Patients were encouraged to do self-exercise and to return to normal daily living conditions. The external fixator was removed after consolidation of the regenerate (bridging of the fracture site by bone, cortical continuity, and no tenderness at the osteotomy site) with documentation of its duration.

All patients were followed up after 3, 6, and 12 months. All postoperative complications were noted. All clinical, radiological, and functional measurements were documented at the time of presentation and the final follow-up and compared with each other.

The Mann–Whitney *U* nonparametric test was used for the statistical analysis. A *P* value of less than 0.05 was reported as statistically significant.

RESULTS

Our study was conducted on 12 patients. There were eight (66.6%) males and four (33.4%) females. The mean age of the patients was 30±2.5 years (range, 20–54 years). The mean follow-up time was 25.2±11 months (range, 12–39 months). After an average duration of 2.5±0.6 months (range, 2–3.5 months), the external fixator was removed (Table 1).

As shown in Table (2), the mean pain value by using the visual analog scale score was 5.3±1.6 (range, 5–8) preoperatively, which improved to 2.4±1.4 (range, 2–4) at the final follow-up. The mean preoperative grip strength was 11.6±3.1kg (range, 10–14kg) compared to 26.2±11.6kg (range, 18–35kg) at the final follow-up. As regards the active range of motion before the surgery versus at the final follow-up, improvements were seen in wrist flexion (44.8±16.8º vs. 60.2±17.8º), wrist extension (39.3±11.2º vs. 70.3±9.2º), forearm pronation (75.3±14.5ºvs. 84.0±7.2º), and forearm supination (16.0±7.5º vs. 79.8±15.5º). According to our results, statistically significant differences could be found as regards pain, grip strength, and active range of motion of the affected wrist between the preoperative measurements and at the final follow-up (*P*=0.01, 0.012, and 0.027, respectively).

Angular deformity improved from a preoperative average of 28±2.457º (range, 21–35) dorsal tilt to an average of 5±2.538º (range, 3–14) palmar tilt at the

final follow-up with a statistically significant difference (P=0.01). Radial inclination improved from an average of 12±6.150º (range, 8–14) preoperatively to 20±9.189º (range, 9–30) at the final follow-up with a statistically significant difference (P=0.01) (Figure 1).

Figure 1: Wrist anteroposterior and lateral radiography showing malunited fracture distal radius; (A): Underwent management by corticotomy and Ilizarov external fixation; (B,C): With gradual correction via lengthening; (D): Based on the principles of distraction osteogenesis till consolidation of the regenerate; (E): With good correction of all radiological measurement after removal of the frame (F).

The mean shortening of the radius was 9±4.150mm (range, 0.5–1.7cm). The mean lengthening was 12±2.189mm (range, 0.7–1.9cm). Apart from two (16.6%) patients, a normal distal radioulnar joint level was established in all patients. A preoperative average of +3.7mm (range, 2–18mm) ulnar variance decreased to +0.62mm (range, 0.1–3mm) at the final follow-up with a statistically significant difference (P=0.017) (Table 2).

The mean DASH score was 50.6±11.478 (range, 40.2–62.9) preoperatively and decreased to 14.3±4.689 (range, 18.6–6.6) at the final follow-up. Mean MMWS was 48.61±6.313 (range, 44.3–52.6) preoperatively and increased to 90.81±5.449 (range, 72.6–96.4) at the last follow-up. According to the interpretation of the MMWS, three (25%) excellent, six (50%) good, and three (25%) fair results were obtained. Statistically significant differences were found between the preoperative measurements and at the final follow-up regarding the DASH score and MMWS score (all P<0.05) (Table 2).

Four patients had a superficial pin tract infection, which was managed with frequent pin site care and oral antibiotics. No deep pin tract infection or neurovascular complications were seen in any patient. One patient was complicated with Sudeck's atrophy and was treated with physiotherapy and medical treatment.

Table 1: Sex, age, duration of external fixator, and length of follow-up of patients:

	All patients (N=12)		
Sex	Male		8(66.6)
	Female		4(33.4)
Age	Mean±SD	Minimum	Maximum
	30±2.5	20	54
Length of follow-up (months)	25.2±11	12	39
Duration of external fixator (months)	2.5±0.6	2	3.5

Table 2: Other data of the studied patients:

	All patients (N=12)		
Mean±SD	**Preoperative**	**The final follow-up**	***P***
Clinical			
VAS score	5.3±1.6	2.4±1.4	0.01*
Grip strength (kg)	11.6±3.1	26.2±11.6	0.012*
Range of motion (deg.)			
Wrist flexion	44.8±16.8	60.2±17.8	0.027*
Wrist extension	39.3±11.2	70.3±9.2	
Pronation	75.3±14.5	84.0±7.2	
Supination	16.0±7.5	79.8±15.5	
Radiological			
Palmar tilt (deg.)	+28±2.457	−5±2.538	0.01*
Radial inclination (deg.)	12±6.150	20±9.189	0.01*
Radial length (mm)	9±4.150	12±2.189	0.0001*
Ulnar variance (mm)	3.7±0.330	0.62±0.390	0.017*
Functional			
DASH score	50.6±11.478	14.3±4.689	0.014*
MMWS score	48.61±6.313	90.81±5.449	0.001*

DASH: Disabilities of the Arm, Shoulder and Hand; MMWS: Modified Mayo Wrist Score; VAS: Visual Analog Scale; *: Statistically Significant.

DISCUSSION

The correction of palmar tilt was statistically significant in the current study. It improved from an average of 28±2.457º dorsal tilt preoperatively to an average of 5±2.538º of palmar tilt at the final follow-up. This could be achieved by proper osteotomy hinge placement, as it determines the axis of correction. Also, there was a significant improvement in the radial inclination angle. Our results were comparable with those of Lubahn *et al*., [12], who treated 20 patients using the principles of distraction osteogenesis.

Malunited distal radius fractures result in biomechanical alterations and increased stress at both distal radioulnar and radiocarpal joints, with a resultant functional disability that correlates with the amount of residual deformity [13,14].

In the current study, we included symptomatic patients complaining of pain and functional limitations. The wrist pain is associated with shortening of the radius and palmar angle loss [15].

The main objective of the operative management for distal radius malunion is to reorient the joint surface for the restoration of normal load transmission and reestablishment of normal carpal kinematics and distal radioulnar function [16].

According to our results, we achieved significant improvement as regards pain, grip strength, and active range of motion of the affected wrist, which was comparable with those of other studies reporting the results of corrective osteotomy with fixation for management of malunited distal radius fracture [17–19].

The external fixation was removed after healing with a mean duration of 2.5±0.6 months, which was similar to the study conducted by Arslan *et al*., [20].

Numerous surgical techniques have been used for the treatment of malunited distal radius. Each procedure has its area of application, advantages, and disadvantages [21]. The most common technique for dorsal angulation deformity after an extra-articular fracture malunion is a distal radial osteotomy and fixation with a volar plate [22,23]. However, this technique could be technically demanding and has been associated with nonunion, failure to achieve full correction, and rupture of the extensor pollicis longus [24,25].

The maximum distal radius lengthening that can be obtained from osteotomy is 6–7mm. When radial shortening is more than this range, the residual radial shortening will lead to residual radioulnar problems after treatment [26]. Radial osteotomy could be combined with ulnar shortening when more lengthening is required. This combined procedure may be complicated by incomplete correction, nonunion, hardware failure, and infection [27].

Also, Robinson *et al*., [28] in 2021 recommended an ulnar shortening osteotomy in spite of the fact that they obtained a maximum osteotomy gap of 8.8 mm by a volar distraction device after the application of a volar plate. In our study, we obtained a radius lengthening that ranged from 0.7 to 1.9cm. This was also matched with the results of Lubahn *et al.,* [12].

Classical osteotomies of the distal radius require bone graft. These procedures are complicated with subsequent graft site morbidity (11–28%) and nonunion [29].

Some authors recommend the treatment by osteotomy and plating without bone graft [30,31]. They explained this by the locking plate's rigidity and the high vascularity of the distal radius.

As regards the functional results, significant improvements in the DASH and Mayo scores were found, which were similar to other reports of the functional results of different operative techniques for malunited distal radius [32,33].

Our study was a retrospective study including a few patients. We need a larger comparative study and a longer follow-up.

CONCLUSION

In conclusion, distal radial osteotomy and distraction osteogenesis with the Ilizarov technique used in the current study is a simple technique which could achieve the necessary lengthening of the radius with minimal surgery. Unlike the other methods, this one does not require a second operation for removal of the plate and screws. Also, it eliminates the complications of bone grafting, as there is no need for bone grafting in this technique.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCE

1. Mulders MAM., Detering R., Rikli DA., Rosenwasser MP., Goslings JC., Schep NWL. (2018). Association between radiological and patient-reported outcome in adults with a displaced distal radius fracture: a systematic review and meta-analysis. J Hand Surg Am; 43:710–719.
2. Haase SC., Chung KC. (2012). Management of malunions of the distal radius. Hand Clin; 28:207–216.
3. Evans BT., Jupiter JB. (2019). Best approaches in distal radius fracture malunions. Curr Rev Musculoskelet Med; 12:198–203.
4. Slagel BE., Luenam S., Pichora DR. (2010). Management of post-traumatic malunion of fractures of the distal radius. Hand Clin; 26:71–84.
5. Kiliç A., Kabukçuoğlu YS., Gül M., Sökücü S., Ozdoğan U. (2011). Fixed-angle volar plates in corrective osteotomies of malunions of dorsally angulated distal radius fractures. Acta Orthop Traumatol Turc; 45:297–303.
6. Haghverdian JC., Hsu JY., Harness NG. (2019). Complications of corrective osteotomies for extra-articular distal radius malunion. J Hand Surg Am; 44:987.

7. Arrington ED., Smith WJ., Chambers HG., Bucknell AL., Davino NA. (1996). Complications of iliac crest bone graft harvesting. Clin Orthop Relat Res; 329:300–309.
8. Knirk JL., Jupiter JB. (1986). Intra-articular fracture of the distal end of the radius in young adults. J Bone Jt Surg Am; 68–A:647–659.
9. Noback PC., Cuellar DO., Lombardi JM., Swart EF., Rosenwasser MP. (2015). Evaluating pain in orthopedic patients: can the visual analog scale be used as a long-term outcome instrument. J Pain Relief; 4:182.
10. Hudak PL., Amadio PC., Bombardier C. (1996). Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper Extremity Collaborative Group (UECG). Am J Ind Med; 29:602–608.
11. Slutsky DJ. (2013). Outcomes assessment in wrist surgery. J Wrist Surg; 2:1–4.
12. Lubahn JD., Hood JM., Nechleba J., Williams DP., Green T. (2007). Gradual reduction of distal radial malunion using distraction osteogenesis. J Hand Surg Am; 32:795–800.
13. Pogue DJ., Viegas SF., Patterson RM., Peterson PD., Jenkins DK., Sweo TD., *et al*. (1990). Effects of distal radius fracture malunion on wrist joint mechanics. J Hand Surg; 15A:721–727.
14. Crisco JJ., Moore DC., Marai GE., Laidlaw DH., Akelman E., Weiss AP., Wolfe SW. (2007). Effects of distal radius malunion on distal radioulnar joint mechanics – an in vivo study. J Orthop Res; 25:547–555.
15. Ali M., Brogren E., Wagner P., Atroshi I. (2018). Association between distal radial fracture malunion and patient-reported activity limitations: a long-term follow-up. J Bone Joint Surg Am; 100:633–639.
16. Prommersberger KJ., Pillukat T., Muhldorfer M., van Schoonhoven J. (2012). Malunion of the distal radius. Arch Orthop Trauma Surg; 132:693–702.
17. Mulders MA., d'Ailly PN., Cleffken BI., Schep NW. (2017). Corrective osteotomy is an effective method of treating distal radius malunions with good long-term functional results. Injury; 48:731–737.
18. Vos DI., Tiren D. (2014). Correction osteotomy of distal radius malunion stabilised with dorsal locking plates without grafting. Strat Trauma Limb Reconstr; 9:53–58.
19. Krimmer H., Schandl R., Wolters R. (2020). Corrective osteotomy after malunited distal radius fractures. Arch Orthop Trauma Surg; 140:675–680.
20. Arslan H., Subasi M., Kesemenli C., Kapukaya A., Necmioglu S. (2003). Distraction osteotomy for malunion of the distal end of the radius with radial shortening. Acta Orthop Belg; 69:23–28.
21. Schmal H., Brix M., Bue M., Ekman A., Ferreira N., Gottlieb H., *et al*. (2020). Nonunion – consensus from the 4th annual meeting of the Danish Orthopaedic Trauma Society. EFORT Open Rev; 5:46–57.
22. Osada D., Kamei S., Takai M., Tomizawa K., Tamai K. (2007). Malunited fractures of the distal radius treated with corrective osteotomy using volar locking plate and a corticocancellous bone graft following immediate mobilisation. Hand Surg; 12:183–190.
23. Lozano-Calderón SA., Brouwer KM., Doornberg JN., Goslings JC., Kloen P., Jupiter JB. (2010). Long-term outcomes of corrective osteotomy for the treatment of distal radius malunion. J Hand Surg Eur Vol; 35:370–380.
24. Schurko BM., Lechtig A., Chen NC., Earp BE., Kanj WW., Harper CM., Rozental TD. (2020). Outcomes and complications following volar and dorsal osteotomy for symptomatic distal radius malunions: a comparative study. J Hand Surg Am; 45:158.
25. Rivlin M., Fernández DL., Nagy L., Graña GL., Jupiter J. (2016). Extensor pollicis longus ruptures following distal radius osteotomy through a volar approach. J Hand Surg Am; 41:395–398.
26. Flinkkila T., Raatikainen T., Kaarela O. (2000). Corrective osteotomy for malunion of the distal radius. Arch Orthop Trauma Surg; 120:123–126.
27. Hove LM., Engesaeter LB. (1997). Corrective osteotomies after injuries of the distal radial physis in children. J Hand Surg; 22-B:699–704.
28. Robinson LP., Usmani RH., Fehrenbacher V., Protzer L. (2021). Simplifying the volar distraction osteotomy for distal radius malunion repair. J Wrist Surg; 11:185–190.
29. Suda AJ., Schamberger CT., Viergutz T. (2019). Donor site complications following anterior iliac crest bone graft for treatment of distal radius fractures. Arch Orthop Trauma Surg; 139:423–428.
30. Tarallo L., Mugnai R., Adani R., Catani F. (2014). Malunited extra-articular distal radius fractures: corrective osteotomies using volar locking plate. J Orthop Traumatol; 15:285–290.
31. Taleb C., Zemirline A., Lebailly F., Bodin F., Facca S., Gouzou S., Liverneaux P. (2015). Minimally invasive osteotomy for distal radius malunion: a preliminary series of 9 cases. Orthop Traumatol Surg Res; 101:861–865.
32. Samy M. (2023). Corrective osteotomy of dorsal malunited fractures of the distal end radius using volar locking plate and bone block graft substitute. Menouf Med J; 36:39–43.
33. McQueen MM., Wakefield A. (2008). Distal radial osteotomy for malunion using non-bridging external fixation: good results in 23 patients. Acta Orthop; 79:390–395.