

Treatment of Distal Radius Fracture Nonunion With Posterior Interosseous Bone Flap

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Abstract

Background: Nonunion of distal radius fractures is disabling. Treatment is difficult and the results are not predictable. However, posterior interosseous bone flap (PIBF) has been successful in treating forearm nonunion.

Objectives: To treat distal radius fracture nonunion with PIBF as a new procedure.

Patients and Methods: This prospective non-randomized cohort study was performed at two hospitals in Tehran between January 2011 and September 2015. PIBFs were applied in nine patients (10 nonunions) with a mean age of 55 years. Union success rate, grip strength, wrist range of motion, and forearm rotation were then evaluated.

Results: Although four of the patients had a history of infection, all participants achieved fracture union at a mean time of 3.8 months. Grip strength improved by 12.4 kg. There was also 36° improvement in wrist flexion, 20° improvement in wrist extension, 60° improvement in forearm supination, and 46° improvement in forearm pronation. The range of motion and grip strength improvements were significant.

Conclusions: Pedicled PIBF is a new option for treating distal radius fracture nonunion. The results are predictable in achieving union and good function, and this technique can be successfully used in cases with extensive soft-tissue damage or infection.

Keywords: Distal Radius Fracture, Nonunion, Posterior Interosseous Flap, Treatment

1. Background

Distal radius fracture nonunion is uncommon, occurring in less than 1% of fractures (1). Several factors related to the patient, the injury, and the treatments are involved in the development of distal radius nonunion. These patients have severe dysfunction related to deformity, instability, and pain (2).

Although several studies have described surgical treatments for achieving union (3-5), the results of such attempts are not entirely predictable for distal radius fractures (2). The complication rate increases when there is < 5 mm of subchondral bone supporting the articular surface distal to the nonunion site (2). Some authors recommend total wrist arthrodesis in this situation (4).

Posterior interosseous bone flap (PIBF) has been used successfully as a novel technique to treat forearm bone nonunion, even in infected cases (6, 7). A vascularized bone graft has advantages over a conventional bone graft in the presence of vascularity and living osteocytes (6, 8). However, removing the ulna's distal end during the Darrach procedure or the Sauve-Kapandji procedure is a well-known technique in severe radial shortening, especially in

elderly and osteoporotic patients (9-11). Considering the difficulty of treating distal radius nonunion and the successful use of PIBF of the distal ulna for treatment of complicated forearm nonunions, we decided to use this technique for treatment of distal radius nonunions.

2. Objectives

The aim of this study was to use PIBF to treat distal radius nonunion with the excised distal ulna, which would be useless otherwise.

3. Patients and Methods

This prospective nonrandomized cohort study was carried out at Shariati and Milad Hospitals in Tehran between January 2011 and September 2015. Both hospitals are public general referral hospitals. The participants were nine patients with 10 distal radius nonunions, with a mean age of 55 years (34-78 years). The injuries were caused by falling from a height in four patients and high-energy motor vehicle accidents (MVs) in four patients (five fractures), which

caused open fracture of the distal radius, and by a pathologic fracture in one patient (Table 1).

Initial treatment consisted of application of an external fixator on the distal radius fracture in six patients, plating in two patients, and percutaneous pinning in one patient. Three patients with open fractures had a history of infection, not active at the time of surgery. The patient with a pathologic fracture had a giant-cell tumor of the distal radius, which had been resected and replaced by distal radius allograft. He had been referred to us due to allograft nonunion. The patient who had been treated by percutaneous pinning was diabetic and had a segmental distal radius nonunion.

There were no concomitant neurovascular injuries except in one patient, who had ulnar nerve injury. All patients complained of pain, four complained of instability, and five complained of weakness. The average time between injury and referral to our center was nine months.

3.1. Surgical Technique

The site of nonunion was exposed using the Henry volar approach, except in three cases in which arthrodesis was performed with a dorsal approach (patient numbers 3 and 8, and the left side of patient number 2). The distal fragment was freshened by removal of fibrous tissues and by bone curettage. A small part of the proximal area was removed to expose normal-appearing bone. We then fixed the nonunion site using a locking T-plate for nonunion fixations and a reconstruction plate for arthrodesis. A segment of the distal ulna was harvested via the antegrade PIBF technique.

In order to harvest the antegrade PIBF, the plane between the extensor carpi ulnaris and the extensor digiti minimi was developed distally. The posterior interosseous artery and its branches to the ulna periosteum were then identified. The desired graft length was chosen, and the vascularized bone flap was cut from the distal ulna. A distal segment of ulna was removed on the posterior interosseous pedicle base to perform the Darrach procedure or the Sauve-Kapandji procedure (7). Depending on the size of the distal fragment and the space gap between the two segments, we used the vascularized bone graft as an onlay bone graft in three nonunions and as an intercalary bone graft in seven. In patient number 3, who had a pathologic fracture and an allograft, radiocarpal joint arthrodesis was performed.

3.2. Follow-up Evaluation

After the surgery, the patients were splinted for one week, then free range of motion was allowed. The patients were evaluated every six weeks until union occurred. At

each followup visit, we evaluated each patient with radiographic and clinical examinations. The range of motion of each upper extremity was measured with a goniometer, based on wrist flexion and extension and on forearm supination and pronation. Grip power was assessed with a Jamar dynamometer device (Patterson Medical). This device is periodically calibrated by a committee at the Joint Reconstruction Research Center, Tehran University of Medical Sciences. Post-operative measurements were compared with pre-operative findings. We checked the nonunion site radiographically with anteroposterior, lateral, and two oblique views. If three cortices were united, the fracture was considered to be healed (Figure 1). The clinical and radiological assessments were performed by one observer for all patients.

4. Results

All patients achieved fracture union at a mean time of 3.8 months (range 3-6 months) (Table 2). Mean follow-up time was nine months (6-18 months). Wrist arthrodesis was performed in three patients due to distal radius cartilage destruction. Infection was the cause of destruction in patient number 8 and on the left side in patient number 2. Allograft cartilage was destroyed due to nonunion in patient number 3.

Mean flexion range of motion improved from 14° before the surgery to 34° post-operatively. Mean extension range improved from 17° to 43°, supination improved from 22° to 82°, and pronation improved from 21° to 67°. Grip strength improved from 2.7 kg before surgery to 15.3 kg at the final follow-up. The improvements in range of motion and grip strength were significant ($P < 0.001$). We did not observe any complications, such as infection (even in cases with a history of infection), synostosis, or iatrogenic fracture.

5. Discussion

Distal radius fracture nonunion is rare. Bacorn and Kurtzke reported a nonunion rate of 0.2% in a study of more than 2,000 fractures of the distal end of the radius (1). The low incidence of distal radius nonunion can be attributed to many factors, including impact of the fracture fragments, their location in the metaphyseal bone, and the fact that they typically result from low-energy falls, indicating less soft-tissue disruption (2).

The results of attempts to achieve distal radius union are not entirely predictable. Smith and Wright reported five cases of distal radius nonunion, two of which failed treatment and required wrist fusion (12). Segalman and

Table 1. Patient Information

Patient Number	Age, y	Mechanism of Injury	Injured Limb (Right/Left)	Previous Treatments	Accompanying Lesion	Chief Complaint
1	34	MVA	R	Ext. fix.	Infection	Pain, instability
2	40	MVA	R & L	Ext. fix.	Infection	Pain, weakness
3	34	Pathologic fracture	R	Allograft + plate	Giant-cell tumor	Pain, weakness
4	67	Fall	R	Ext. fix.	Diabetes mellitus	Pain, weakness
5	78	Fall	L	PCP	Segmental nonunion	Pain, instability
6	62	Fall	L	Ext. fix.	-	Pain, instability
7	38	Fall	R	Ext. fix.	-	Pain, weakness
8	42	MVA	R	Ext. fix.	Infection	Pain, weakness
9	61	MVA	L	ORIF	-	Pain, instability

Abbreviations: MVA, motor vehicle accident; ORIF, open reduction and internal fixation; Ext. fix., external fixation.



Figure 1. Radiography of Distal Radius Nonunion with Significant Shortening (A), After Reconstruction with PIBF (B), and After Union of the Nonunion Site (C)

Clark used the size of the metaphyseal subchondral bone of the articular surface distal to the site of the nonunion as a criterion to determine the appropriate treatment. They suggested that surgical attempts to achieve bony union are worthwhile when at least 5 mm of subchondral bone beneath the distal radius lunate facet is available for the application of implants. Otherwise, they recommended total

wrist arthrodesis (4).

In a study of 23 distal radius nonunions, Prommersberger and colleagues reported unsatisfactory treatment results for six patients (13). They did not find distal fragment size to have an effect on functional or radiographic results, but observed more post-operative complications when distal fragments were small. Crow and col-

Table 2. Clinical Results

Patient Number	Wrist Flexion (°, Before/After)	Wrist Extension (°, Before/After)	Supination (°, Before/After)	Pronation (°, Before/After)	Grip Power (Kg, Before/After)	Time Until Union (Months)
1	30/30	40/60	40/90	50/90	6/18	3
2 R	20/50	30/60	0/90	10/40	2/20	3
2 L	0/20, Radiolunate arthrodesis	20/10, Radiolunate arthrodesis	40/90	10/60	2/15	4
3	40/0, Wrist arthrodesis	15/20, Wrist arthrodesis	30/90	40/90	3/12	3
4	15/50	5/45	10/70	10/40	0/10	6
5	5/30	5/30	10/70	10/70	5/18	4
6	15/30	5/60	30/60	10/60	0/5	5
7	10/30	20/40	30/90	30/90	2/20	3
8	10/0, Wrist arthrodesis	20/20, Wrist arthrodesis	10/80	20/40	5/15	4
9	15/30	10/40	20/90	20/90	2/20	3

leagues reported using a vascularized bone flap of a second metacarpal base for treating distal radius nonunion in one case, and achieved good results (14). Removing a segment of the distal ulna has been suggested as a treatment for severe radial shortening (9-11).

Recently, Kamrani and colleagues used posterior interosseous vascularized bone flaps for treating forearm bones (6). They also successfully used PIBFs in infected forearm bone nonunions (7). In the present study, we used PIBF to treat distal radius nonunions in nine patients, in order to obtain more predictable results. We achieved union in all cases despite their diversity, including a history of infection in three cases, pathologic fractures, and allograft nonunions. Although we had to perform wrist arthrodesis in three patients due to a lack of articular cartilage, union was achieved at the fracture site. We performed radiolunate arthrodesis in one patient (the left side of patient number 2), and after union, he gained some range of motion. Improvements in range of motion and grip strength were significant in all patients ($P < 0.001$).

Pedicled PIBF has many advantages. It does not require a complex microsurgical procedure (such as free fibular flaps), does not require the sacrifice of a major artery, rarely induces donor-site morbidity, and can be completed in one operative field under regional anesthesia. It can also be performed in elderly individuals. In cases with extensive soft-tissue damage or infection, pedicled PIBF could be used successfully, although more studies are required.

Pedicled PIBF is a new option for treating distal radius nonunions. The treatment results are predictable and this technique can be successfully used in cases with extensive soft-tissue damage or infection. The inclusion of com-

plicated cases of distal radius nonunion with extensive soft-tissue damage or infection were a strong point of our study, which demonstrates the efficacy of this new method for treating this condition. Since distal radius nonunions are uncommon, we recommend using this new method in a multi-centered study to consider its potential as a universal treatment for complicated cases.

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Footnote

Conflict of Interest: The authors have no conflict of interest.

References

- Bacorn RW, Kurtzke JF. Colles' fracture; a study of two thousand cases from the New York State Workmen's Compensation Board. *J Bone Joint Surg Am.* 1953;35-A(3):643-58. [PubMed: 13069552].
- Prommersberger KJ, Fernandez DL. Nonunion of distal radius fractures. *Clin Orthop Relat Res.* 2004(419):51-6. [PubMed: 15021131].
- Saleh M, Ribbans WJ, Meffert RH. Bundle nailing in nonunion of the distal radius: case report. *Handchir Mikrochir Plast Chir.* 1992;24(5):273-5. [PubMed: 1427469].
- Segalman KA, Clark GL. Un-united fractures of the distal radius: a report of 12 cases. *J Hand Surg Am.* 1998;23(5):914-9. doi: 10.1016/S0363-5023(98)80173-1. [PubMed: 9763272].
- McKee MD, Waddell JP, Yoo D, Richards RR. Nonunion of distal radial fractures associated with distal ulnar shaft fractures: a report of four cases. *J Orthop Trauma.* 1997;11(1):49-53. [PubMed: 8990035].

6. Kamrani RS, Mehrpour SR, Sorbi R, Aghamirsalim M, Farhadi L. Treatment of nonunion of the forearm bones with posterior interosseous bone flap. *J Orthop Sci.* 2013;**18**(4):563-8. doi: [10.1007/s00776-013-0395-0](https://doi.org/10.1007/s00776-013-0395-0). [PubMed: [23604642](https://pubmed.ncbi.nlm.nih.gov/23604642/)].
7. Kamrani RS, Farhoud A, Nabian MH, Zanjani LO, Farzan M. Vascularized posterior interosseous pedicled bone grafting for infected forearm nonunion. *J Hand Surg Eur Vol.* 2016;**41**(4):441-7. doi: [10.1177/1753193415601041](https://doi.org/10.1177/1753193415601041). [PubMed: [26307139](https://pubmed.ncbi.nlm.nih.gov/26307139/)].
8. Mullett H, Hausman M, Zaidemberg C. Recalcitrant distal humeral and proximal forearm nonunion: salvage using an extended pedicled radial forearm osseous flap. *J Trauma.* 2008;**64**(4):60-4. doi: [10.1097/01.ta.0000229713.56091.5b](https://doi.org/10.1097/01.ta.0000229713.56091.5b). [PubMed: [18404046](https://pubmed.ncbi.nlm.nih.gov/18404046/)].
9. DiBenedetto MR, Lubbers LM, Coleman CR. Long-term results of the minimal resection Darrach procedure. *J Hand Surg Am.* 1991;**16**(3):445-50. [PubMed: [1861024](https://pubmed.ncbi.nlm.nih.gov/1861024/)].
10. Tulipan DJ, Eaton RG, Eberhart RE. The Darrach procedure definded: technique redefined and long-term follow-up. *J Hand Surg Am.* 1991;**16**(3):438-44. [PubMed: [1861023](https://pubmed.ncbi.nlm.nih.gov/1861023/)].
11. Lluch A. The Sauve-Kapandji procedure: indications and tips for surgical success. *Hand Clin.* 2010;**26**(4):559-72. doi: [10.1016/j.hcl.2010.07.002](https://doi.org/10.1016/j.hcl.2010.07.002). [PubMed: [20951905](https://pubmed.ncbi.nlm.nih.gov/20951905/)].
12. Smith VA, Wright TW. Nonunion of the distal radius. *J Hand Surg Br.* 1999;**24**(5):601-3. doi: [10.1054/jhsb.1999.0267](https://doi.org/10.1054/jhsb.1999.0267). [PubMed: [10597942](https://pubmed.ncbi.nlm.nih.gov/10597942/)].
13. Prommersberger KJ, Fernandez DL, Ring D, Jupiter JB, Lanz UB. Open reduction and internal fixation of un-united fractures of the distal radius: does the size of the distal fragment affect the result?. *Chir Main.* 2002;**21**(2):113-23. [PubMed: [11980339](https://pubmed.ncbi.nlm.nih.gov/11980339/)].
14. Crow SA, Chen L, Lee JH, Rosenwasser MP. Vascularized bone grafting from the base of the second metacarpal for persistent distal radius nonunion: a case report. *J Orthop Trauma.* 2005;**19**(7):483-6. [PubMed: [16056082](https://pubmed.ncbi.nlm.nih.gov/16056082/)].