Distal Radius Fracture Fixation With the Specialized Threaded Pin Device

John S. Taras, MD; Jason C. Saillant, MD; Peter Goljan, MD; Lucy A. McCabe, BS

abstract

This study investigated the outcomes of extra-articular distal radius fractures and simple intra-articular radial styloid fractures stabilized with a novel threaded cannulated device. This was a retrospective study of 24 distal radius fractures treated with the T-Pin device (Union Surgical LLC, Philadelphia, Pennsylvania), with a minimum of 1 year of postoperative follow-up. Outcome data included wrist range of motion, grip strength, and pinch strength. Radiographs were analyzed to determine volar tilt and radial height. At final follow-up, patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. At an average of 2 years after surgery (range, 1-4 years), flexion was 89%, extension was 96%, supination was 99%, and pronation was 100% of contralateral wrist motion. Grip strength was 93% (range, 40%-137%) and lateral pinch strength was 99% (range, 48%-130%) of the contralateral upper extremity. The average final DASH score was 4.4 (range, 0-35). One patient lost 6 mm of radial height from the initial postoperative radiograph to the final follow-up radiograph. One patient elected to have the quiescent threaded pins removed, and 1 patient had tenderness with wrist range of motion that resolved after pin removal. After hardware removal, neither patient had further symptoms. No postoperative soft tissue complications occurred, and this was an expected benefit of the minimally invasive approach and intramedullary placement of the device. The stability of fixation allows patients to begin active range of motion early in the postoperative course. The threaded pin offers reliable fracture fixation for the treatment of extra-articular and simple articular distal radius fractures. [*Orthopedics*]

It is estimated that 640,000 distal radius fractures occur annually in the United States.[1] Treatment of this injury focuses on fracture reduction and maintenance of reduction in active patients.[2] Closed reduction and casting, percutaneous Kirschner wire fixation with casting, external fixation, and internal fixation are all appropriate treatment options,[3-8] yet neither a recent Cochrane review[9] nor the current American Academy of Orthopaedic Surgeons Clinical Practice Guideline Summary[10] identified any of these methods as superior to the others.

Historically, percutaneous pinning has not shown consistent maintenance of fracture reduction, and several studies have reported loss of reduction after pinning in 25% to 33% of cases.[11-15] To increase stability, treatment methods have shifted toward internal fixation with hardware designed to fix common fracture patterns.[4] Despite improvements in fixation strength, studies of newer techniques did

The authors are from Thomas Jefferson University (JST); Drexel University College of Medicine (JST); and The Philadelphia Hand Center, PC (JST, JCS, PG, LAM), Thomas Jefferson University Hospital, Philadelphia, Pennsylvania.

Drs Saillant and Goljan have no relevant financial relationships to disclose. Dr Taras is owner and founder of Union Surgical, LLC, and has patents for a distraction pin for fracture fixation and the T-Pin. Ms McCabe is a paid consultant for Union Surgical, LLC.

Correspondence should be addressed to: John S. Taras, MD, The Philadelphia Hand Center, PC, Thomas Jefferson University Hospital, 834 Chestnut St, Ste G-114, Philadelphia, PA 19107 (jstaras@handcenters.com).

Received: April 27, 2015; Accepted: June 8, 2015.

doi: 10.3928/01477447-20151222-08

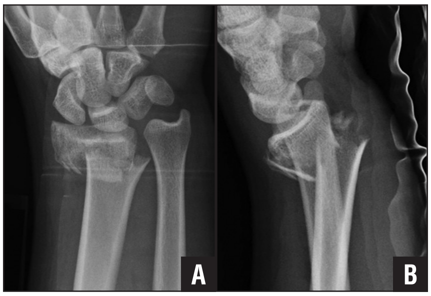

Figure 1: Posteroanterior (A) and lateral (B) radiographs of a typical extra-articular distal radius fracture suitable for fixation with the threaded pin device.

not report significantly better clinical outcomes.[16] Internal fixation is not without complications, including tendon rupture, tenosynovitis, and secondary procedures for hardware removal.[17]

The T-Pin (Union Surgical LLC, Philadelphia, Pennsylvania) is a threaded, cannulated pin designed to stabilize distal radius fractures. Advantages of the threaded pin include the need for smaller surgical exposure compared with other implants, strength to tolerate early postoperative active wrist motion,and comparatively low cost.[18] The thread pitch is uniform and is designed not to compress the fracture, which, in the case of comminution, would cause loss of reduction. This design distinguishes the threaded pin from common headless screws that are intended to apply compression.

Materials and Methods

The institutional review board at the authors' institution approved this study. All patients were enrolled in the study prospectively, and data were reviewed retrospectively for patients who had undergone distal radius fracture fixation with the threaded pin device.

Inclusion Criteria

An extra-articular distal radius fracture was appropriate for threaded pin fixation if it had failed initial closed reduction, had undergone interval displacement to an unacceptable position, or exhibited characteristics that indicated a high likelihood of redisplacement with closed treatment (**Figure 1**).[19] Fracture displacement requiring fixation was defined by dorsal angulation of 10°, volar tilt of 20° perpendicular to the long axis of the fracture, and ulnar variance greater than 2 mm compared with the contralateral side. Medically unstable patients and those who were unable or unwilling to comply with the postoperative protocol were ineligible for inclusion, as were patients with mild dementia and/or difficulty with communication skills.

Functional and Radiographic Data Assessment

A hand therapist or the hand surgery fellow assigned to the senior hand surgeon's clinic at the follow-up visit collected outcome data, including wrist range of motion (flexion, extension, supination, and pronation), grip strength, and lateral pinch strength of the operative and contralateral upper extremities. Wrist range of motion was measured with a standard goniometer. Grip strength was measured with a Jamar hydraulic hand dynamometer (Sammons Preston, Bolingbrook, Illinois) in position 2, and lateral pinch strength was assessed with a pinch gauge (Sammons Preston).

Radial height and volar tilt were determined from plain radiographs taken at each visit with a standard goniometer and ruler. Radial height was measured on a posteroanterior radiograph as the difference between 2 parallel lines, 1 intersecting the distal tip of the radial styloid and the other intersecting the most proximal articular edge of the radius. Volar tilt was measured on a lateral radiograph as the angle between a line connecting the dorsal and volar lips of the radius and a second line perpendicular to the long axis of the radius. Dorsal angulation, or negative radial height, was recorded as a negative value. Radiographs obtained at the first postoperative visit were compared with those taken at final follow-up to assess for loss of reduction. A change in volar tilt of 10° or a loss of radial height of more than 5 mm indicated loss of reduction. At the final follow-up, patients completed the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire.[20]

Patient Selection

The initial study group included 31 patients (31 extra-articular distal radius fractures). Of that group, 3 patients were unable to return to the clinic for 1-year follow-up, and 4 patients were lost to follow-up. At the conclusion of the study, a total of 24 patients (24 nonconsecutive fractures) returned for follow-up at 1 year, and this study reports on that cohort. Of these patients, 5 were men and 19 were women, with a mean age of 56 years (range, 27-76 years). Average patient age was 43 years for men and 59 years for women. Average clinical follow-up was 25 months (range, 12-48 months). In all patients, the right hand was dominant. The right wrist was injured in 6 patients and the left wrist in 18 patients. According to the AO classification system, there were 6 type A2 fractures, 12 type A3 fractures, and 6 type B1 fractures. All fractures resulted from a fall onto an outstretched hand.

Surgical Technique

All patients underwent closed reduction under fluoroscopy. In many cases, percutaneously placed Kirschner wires were used to manipulate the fracture into anatomic reduction. All threaded pins were implanted according to the method described by Taras et al.[18] Anesthesia was achieved by conscious sedation with a local field block. A nonsterile pneumatic tourniquet was applied proximal to the elbow. After anatomic alignment was restored, threaded pins were implanted to stabilize the reduction. A single 1-cm longitudinal incision was made at the distal aspect of the radial styloid between the first and second dorsal extensor compartments. Dissection was carried down to the bone to visualize the pin insertion site, with care taken to protect the superficial radial nerve branches and adjacent extensor tendons. The fracture was temporarily stabilized with smooth 1-mm guide wires included in the surgical set. To determine the appropriate implant length, a measuring guide was applied along each guide wire. The cannulated threaded pin was then placed over the guide wire and drilled into position with a standard power driver. The guide wire was removed, and the smooth driver portion of the threaded pin was manually broken off by bending. Depending on the surgeon's preference and the fracture pattern, a second threaded pin was inserted in a parallel, divergent, or crossed fashion. In 19 cases, 2 threaded pins were placed through a single radial styloid incision (**Figure 2**). In 5 cases, an alternative configuration of 1 threaded pin implanted at the radial styloid and another pin implanted through a second incision at the dorsal ulnar corner of the distal radius was used. Fracture stability was confirmed under fluoroscopy, and the wound was closed in standard fashion. A plaster short arm splint that allowed unrestricted digital range of motion was applied at the conclusion of the procedure and was worn until the first postoperative visit.

Postoperative Protocol

Patients presented for the first postoperative therapy session within 3 days after surgery under the guidance of a hand therapist. Patients were fitted with a thermoplastic volar static wrist splint with the wrist in slight extension. The splint was removable for bathing and exercises. Initial therapy included active and passive digital range of motion, edema control, and gentle wrist active range of motion. Patients were instructed in tendon gliding exercises, gentle midrange forearm rotation, and wrist active range of motion, including radial and ulnar deviation and 30° each of flexion and extension to be performed 4 times daily. Patients were instructed in edema control measures and were told to maintain shoulder and elbow active range of motion.

At 2 weeks postoperatively, patients were advanced beyond the 30° flexion and 30° extension limits as tolerated. If they had wrist discomfort, they were advised to maintain active range of motion limits of 30° flexion and 30° extension. At 4 to 6 weeks postoperatively, patients began to wean from the splint and were advanced to active, active assisted, and gentle passive wrist extension and flexion. By 6 to 8 weeks postoperatively, the splint was discontinued and strengthening exercises were initiated. Eight weeks after surgery, strengthening was continued and upgraded to tolerance. Patients typically were cleared to resume nonforceful activities 6 to 8 weeks after surgery. At discharge, patients were instructed to return for final assessment and radiographs at least 1 year postoperatively.

Results

Patients underwent surgery an average of 7 days after injury (range, 2-14 days). The average duration of follow-up was 25 months (range, 12-72 months). The **Table** summarizes the radiographic findings. Average preoperative volar tilt was dorsal angulation of 19.4° (range, 12.0° volar to 38.7° dorsal), and average preoperative radial height was 4.3 mm (range, -18.0 mm to 15.0 mm). Comparison of initial postoperative radiographs with final follow-up images showed maintenance of reduction in all but 1 patient (4% of fractures), and in this patient, the final radiograph showed a 6-mm loss of radial height (**Figure 3**). The patient's initial radiographs at the time of injury showed an AO type A2 extra-articular fracture. Despite the postoperative decrease in radial height, grip strength and range of motion remained satisfactory, and DASH score 2.7 years after surgery was 2.5. It was not initially appreciated that this patient required weight bearing through both upper extremities to stand up because of hip arthritis. This could explain the loss of height because initial postoperative radiographs showed excellent initial reduction and very good pin placement.

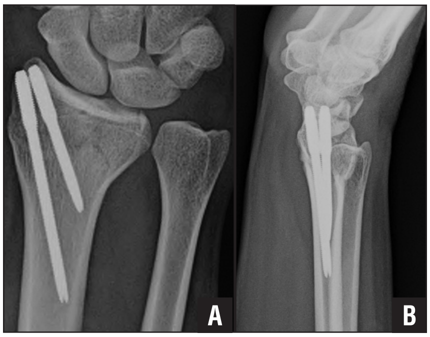

Figure 2: Posteroanterior (A) and lateral (B) radiographs showing the pinning pattern in which 2 threaded pins are implanted through a single 0.5-cm incision over the radial styloid.

The average final DASH score was 4.4 (range, 0-35). One patient with a score of 17.5 (**Figure 4**) had an otherwise uneventful postoperative course, and a patient with a DASH score of 35 (**Figure 5**) required carpal tunnel release 6 months after fracture fixation. This patient did not have concerns about carpal tunnel syndrome until 4 months after surgery and did not have any sensory disturbance at the time of the initial fall or preoperatively. An electromyographic study performed 5 months after distal radius fracture fixation showed a motor latency of 5.2 ms, and the patient's carpal tunnel symptoms resolved postoperatively. One patient reported paresthesias in the superficial radial nerve distribution that resolved within 2 months. One patient in the study requested elective hardware removal 6 months after the initial procedure, and 1 patient's threaded pin was removed 3 years after fixation because of insertion site tenderness and pain with wrist range of motion. After pin removal, the symptoms resolved. At final follow-up 2 weeks after pin removal, the patient had a DASH score of 0.

Discussion

Many options are available to treat distal radius fractures. The volar locking plate has become a popular fixation strategy, given its ability to withstand early mobilization.[5,7,16] Fragment-specific systems enable surgeons to manage com-

Table

Radiographic Measurements

Patient No.	Volar Tilt[a] Preoperative	Volar Tilt[a] Immediate	Volar Tilt[a] Final Follow-up	Radial Length, mm Preoperative	Radial Length, mm Immediate	Radial Length, mm Final Follow-up
1	-18°	0°	0°	-2	0	0
2	0°	14.2°	14°	7	10.5	10.7
3	-9°	14.9°	12°	11	10.2	4.2
4	-30°	7.2°	7°	6	10.4	7.5
5	-20°	2.1°	2°	8	13.5	14
6	12°	8.4°	5°	15	9.9	10
7	-35°	-1.6°	-2°	5	4.5	5
8	-40°	4.3°	2°	8.5	8.2	9
9	-20°	2.4°	3°	7	13.6	15
10	-3.2°	2.6°	4°	7.9	11.1	6.8
11	-10°	11.6°	8.4°	8	9.4	8
12	-32°	8.6°	6°	-18	10.6	9.6
13	7°	17°	17°	-1	2	2
14	-40°	-6.4°	-6°	-3	8.3	7.5
15	-25°	-5.5°	-3.7°	2	6.2	6.1
16	-14°	-1.3°	-2°	6	7.6	8
17	-15°	4.8°	6.9°	10.5	11.9	13.6
18	-29.2°	-0.8°	1.2°	9.2	5.6	4.6
19	-36.1°	3.2°	5.6°	-3.5	7.6	7.7
20	-16°	6.4°	4.4°	7.9	7.7	6.6
21	-29.1°	4°	6.6°	-0.3	7.6	7.4
22	-38.7°	10.5°	11.7°	-3.1	6.3	5.4
23	-26.1°	0.9°	2.1°	7.5	12.3	11.7
24	2°	7.5°	4.5°	6.8	8.4	7.6

[a] *Negative values indicate dorsal angulation.*

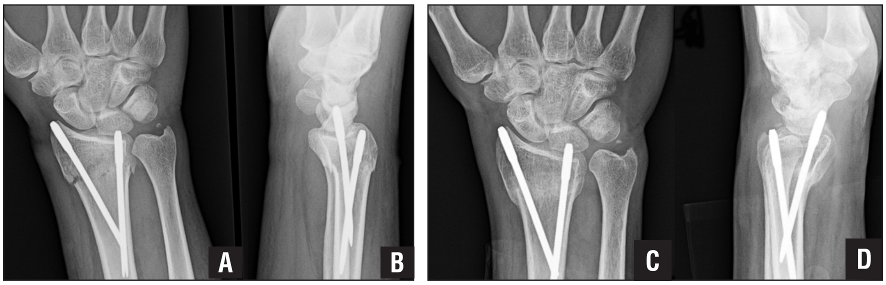

Figure 3: Initial posteroanterior (A) and lateral (B) postoperative radiographs of a noncompliant patient whose final posteroanterior (C) and lateral (D) radiographs showed a 6-mm loss of radial height.

plex fracture patterns and also allow early range of motion.[17,21-25] These fixation methods can provide robust fracture stability but are not without complications. Dorsal plate fixation has been associated with soft tissue irritation and extensor tendon ruptures, and volar plate fixation has interfered with soft tissue structures in the volar and dorsal wrist compartments in some cases.[2,7,26-30] An early study of volar fixation by Orbay and Fernandez[7] reported a low complication rate, but a recent literature review showed complication rates ranging from 4.9% to 27%.[31] Analysis of volar plate positioning raised awareness of its correlation to flexor tendon attrition.[27] Reports of extensor tendon rupture from dorsal cortex screw penetration are well documented.[28,32]

Intramedullary fixation options include the Micronail (Wright, Memphis, Tennessee), the DRS System (Conventus Orthopaedics, Maple Grove, Minnesota), and the WRx Wrist Pin (Sonoma Orthopedic Products, Inc, Santa Rosa, California). Ilyas and Thoder[33] reported that the Micronail could provide good functional outcomes but had a high incidence of complications, with distal screws penetrating the distal radioulnar joint in 30% of cases and superficial radial nerve neuritis occurring in 20% of cases.

After threaded pin fixation, patients showed range of motion, grip strength, radiographic, and functional outcomes equivalent to those reported for volar or dorsal internal fixation.[22,25,34] In this series, 1 of 24 fractures (4%) lost 6 mm of radial height from initial postoperative radiographs to final radiographs, and this incidence is similar to previous studies of internal fixation.[21-24]

Previous studies examined the performance of standard cannulated screws in treating similar fractures.[35,36] In 2 studies by 1 group of surgeons, standard threaded cannulated screws were effective for AO type A2 fracture fixation. Both studies reported equivalent range of motion in the affected and contralateral wrists, no loss of reduction, and average QuickDASH scores of 2.2[36] and 3.8[35] at final follow-up a minimum of 1 year after surgery. One study included a comparative cohort of patients treated with volar locking plates and showed equivalent outcomes at 2 months and 1 year postoperatively.[35] These studies suggest that it may be necessary to develop a more appropriate cannulated screw to meet the requirements of distal radius fracture fixation.[35,36] Based on the favorable results reported in the current study, the threaded pin may represent such a design.

This study was not randomized, and there was no control group. The senior surgeon (J.S.T.) developed the threaded pin and is proficient with nuances of the technique. Proper patient selection and recognition of the appropriate fracture classification are important factors for success with the threaded pin. Surgical issues in threaded pin fixation include the inability to visualize fracture reduction directly and reliance on fluoroscopy to evaluate pin placement and reduction quality.

The threaded pin provides reliable fracture stability that allows patients to begin range of motion early in the postoperative course. Further, intramedullary placement of the threaded pin obviates some of the complications that are commonly seen with percutaneously placed Kirschner wires, such as pin tract infections and the need for hardware removal.

Preliminary analysis of the timelines for threaded pin and volar plate rehabilitation showed that patients treated with the threaded pin were discharged from therapy an average of 68 days postoperatively compared with 132 days postoperatively in patients treated with volar plate fixation. At discharge, both groups showed equivalent wrist active range of motion, but grip strength and pinch strength were stronger in the threaded pin fixation group.[37] These short-term outcomes differ from a recently published randomized controlled trial that compared volar plate fixation with closed reduction and percutaneous pinning.[25] Rozental et al[25] found that although 1-year outcomes were equivalent, patients treated with closed reduction and percutaneous pin fixation had higher initial DASH scores and less improvement in range of motion than those treated with volar plating during the early months of recovery.

The T-Pin is well suited to the treatment of extra-articular (AO type A) fractures.

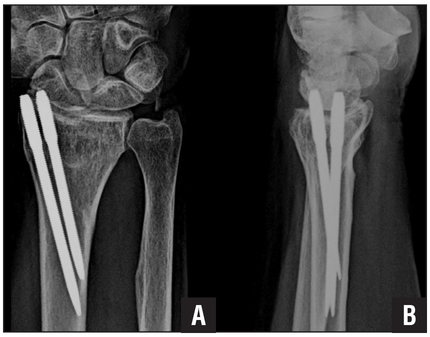

Figure 4: Final posteroanterior (A) and lateral (B) radiographs of a patient whose final Disabilities of the Arm, Shoulder and Hand score was 17.5.

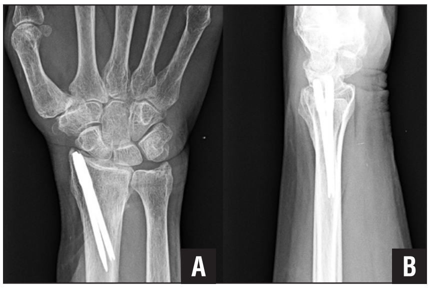

Figure 5: Final posteroanterior (A) and lateral (B) radiographs of a patient whose final Disabilities of the Arm, Shoulder and Hand score was 35. The patient required carpal tunnel release 6 months after fracture fixation.

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