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Original Article

Treatment of extra-articular distal radius fractures using an intramedullary nail

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ABSTRACT

Background: Distal radius fractures are a common fracture type, but an optimal surgical recommendation remains elusive. Intramedullary fixation is a novel technique for treatment of distal radius fractures. The present study aimed to evaluate the clinical results in the management of extra-articular fractures of the distal radius using the intramedullary nail device.

Methods: From June 2009 to July 2010, 12 patients with extra-articular fractures of the distal radius were included. Surgical reduction and internal fixation with an intramedullary nail, the Micronail, was performed primarily for treatment of five AO Type A2 and seven AO Type A3 distal radius fractures. All patients were followed up radiographically and clinically for an average of 48.5 weeks.

Results: All fractures achieved bone union without major complication. The functional results according to the Mayo wrist scoring system were excellent in six patients, good in two patients, and fair in four patients (4/12). The mean score was 84, and the satisfactory functional result was 75%.

Conclusion: Surgical reduction and internal fixation with the intramedullary nail is a useful and effective technique in the management of extra-articular fractures of the distal radius.

1. Introduction

Distal radius fractures are among the most common types of skeletal trauma, accounting for about 20% of all acute fractures and 75% of all forearm fractures. Patients affected by these fractures have a bimodal age distribution, and the incidence increases in the 4th decade of life.[1] The injury is typically caused either by low-energy trauma, such as a fall onto an outstretched hand, or by a high-energy trauma, such as that from a motor vehicle accident. Treatment options for these fractures that are reported to yield satisfactory results include closed reduction and casting, percutaneous pin fixation, open reduction and internal fixation with a plate, bone-grafting, or external fixation.[2] Recently, there has been increasing interest in the use of intramedullary (IM) fixation devices for treatment of distal radius fractures. The benefits of treatment with these devices include a limited requirement for soft tissue dissection, a low-profile implant with low risk of post-operative soft tissue dissection, divergent subchondral screw placement, and locked fixed-angle fixation.[3] In this retrospective study, we report the surgical results and evaluate the potential advantages of IM nail devices used for the management of extra-articular distal radius fractures in 12 patients.

2. Materials and methods

Between June 2009 and July 2010, a single surgeon treated 12 patients with unstable distal radius fractures (Table 1) using an IM fixation device (Micronail; Wright Medical Technologies, Arlington, TN, USA). Included in the study were four men and eight women with an average age of 64 years (range 50–85 years). There were two patients with right wrist fractures and 10 patients with left wrist fractures. There were five AO Type A2 and seven AO Type A3 fractures, according to the AO fracture classification.[4] All fractures resulted either from simple falls onto outstretched hands or from traffic accidents. The mean time between injury and surgery was 5.5 weeks (range 0–22 weeks). The average follow-up period was 48.5 weeks (range 16–65 weeks).

2.1. Surgical procedure

Under general anesthesia, the patient lay in a supine position with aseptic draping and a pneumatic tourniquet were applied. All surgeries were performed with fluoroscopic assistance. Prior to insertion of the Micronail, manual reduction was performed and confirmed with c-arm fluoroscopy. After anatomic reduction, the fracture site was provisionally fixed with percutaneous Kirschner

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Table 1
Demographic data of 12 patients with fractures of the distal radius treated with intramedullary nails.

Patient no.	Age (y)	Sex	Wrist	AO fracture classification	Time to surgery (wk)	Bone union (wk)	Follow-up (wk)
1	73	F	Left	A3	1	6	45
2	66	F	Left	A3	3	12	65
3	65	M	Left	A3	22	6	48
4	70	F	Left	A3	2	6	60
5	82	M	Left	A2	6	6	60
6	59	F	Left	A2	4	12	52
7	50	F	Right	A3	2	12	48
8	60	F	Left	A2	6	12	52
9	50	M	Right	A2	2	10	48
10	58	F	Left	A2	10	12	40
11	71	F	Left	A3	7	12	48
12	67	M	Left	A3	1	9	16
Mean	64 years	4 M; 8 F	2 R; 10 L	5 A2; 7 A3	5.5 weeks	9 weeks	48.5 weeks

wires (Fig. 1). If satisfactory realignment could not be achieved by simple closed manipulation, a small dorsal incision was made between the third and fourth dorsal extensor compartments and a Kirschner wire or periosteum freer was applied to joystick the fracture site. Once the fracture was properly reduced and stabilized, a 2-cm dorso-radial skin incision over the radial styloid process area was made with meticulous protection of superficial radial sensory nerve. Dissection through the interval of the first and second dorsal extensor compartments was made using a starter awl in order to create a cortical bone window. After sizing and trialing by tapping sequential broaches into the IM canal, a Micronail of the measured size was gently inserted through the pretaped track into the medullary canal of the distal radius. Three distal fixed-angle locking screws and two proximal interlocking screws were then applied. C-arm fluoroscopy was used to confirm implant position and to avoid screw penetration into the radiocarpal or distal radioulnar joint. Then all provisionally transfixed Kirschner wires were removed and the guide system was dissembled from the IM nail.

2.2. Postoperative evaluation and follow-up

All patients were fitted with a short arm splint for temporary protection postoperatively. Postoperative rehabilitation with active finger motion training was started immediately. At 10–14 days after surgery, the splint and sutures were removed. Posterior–anterior and lateral radiographs of the injured wrist were

Fig. 1. Radiographs of a 73-year-old woman (Case 1) with AO Type A3 distal radius fracture with ulnar head fracture. (A) Preoperative radiograph, (B) intraoperative C-arm fluoroscopy showing provisional pinning after manipulated reduction, and (C) sequential broach tapering.

performed for all 12 patients preoperatively, and at 6 weeks, 12 weeks, and 16 weeks postoperatively at outpatient clinics. Three radiographic parameters were recorded: radial height, radial inclination, and volar tilt. Bone healing was evaluated and radiographic union was confirmed by trabecular bridging of the fractures. Functional evaluation was performed using the modified Mayo wrist scoring system (Table 2). The grip strength of the injured side was measured and reported as a percentage of the maximal strength of the contralateral side. Pain was self-reported and graded with the use of a questionnaire. The Mayo Wrist Scoring Chart, with the addition of a satisfaction score, was used for functional assessment. Functional results were graded in each of four categories, yielding a total score between 0 and 100.[5]

3. Results

The average follow-up period was 48.5 weeks (range 16–65 weeks). The fractures healed, and pain-free motion resumed in all 12 patients (Fig. 2). There were no major complications, such as wound infection, loss of reduction, implant failure, or complex regional pain syndrome. Minor complications included four patients with transient superficial radial nerve irritation. The symptoms resolved gradually in the early follow-up period. There were no cases of screw penetration into the radiocarpal or distal radioulnar joint. The mean fracture union time was 9 weeks (range 6–12 weeks). Details of the preoperative and postoperative radiographic radial height, radial inclination, and volar tilt measurements, along with the Mayo score of functional outcome, are shown in Table 3. Radial height averaged 8 mm (range 1–11 mm) preoperatively and 10 mm (range 8–12 mm) postoperatively. Radial inclination averaged 15° (range 2–22°) preoperatively and 15° (range 16–24°) postoperatively. The mean volar tilt was −5° degrees (range −30° to 22°) preoperatively and 0° (range −8° to 6°) postoperatively. The overall clinical and functional results according to the Mayo wrist scoring system were excellent in six patients, good in two, and fair in four patients. The average score on the Mayo wrist scoring system was 84 (range 65–100). Procedures yielded satisfactory functional results in 67% of patients (8/12).

Table 2
Modified Mayo wrist scoring system.

Category	Score	Findings
Pain (25 points)	25	No pain
	20	Mild pain with vigorous activities; or pain only with weather changes
	15	Moderate pain with activity
	10	Mild pain with activities of daily living
	5	Moderate pain with activities of daily living
	0	Pain at rest
Satisfaction (25 points)	25	Very satisfied
	20	Moderately satisfied
	10	Not satisfied, but able to work
	0	Not satisfied, unable to work
Range of motion (25 points)	25	100% normal
	15	75–99% normal
	10	50–74% normal
	5	25–49% normal
	0	0–24% normal
Grip strength (25 points)	25	100% normal
	15	75–99% normal
	10	50–74% normal
	5	25–49% normal
	0	0–24% normal

Grading: total score of 90–100 = excellent; 80–89 = good; 65–79 = fair; <65, poor.

4. Discussion

The primary goals in treatment of distal radius fractures are to maintain alignment after fracture reduction and to prevent secondary displacement. There are some disadvantages and limitations to traditional treatment options. Closed reduction and casting may cause wrist stiffness, muscle atrophy, and disuse osteopenia, due to prolonged immobilization.[2,6] This method is therefore commonly adopted for sedentary patients. External fixation, with or without K-wire fixation, is reported to be related to chronic regional pain syndrome that results from overdistraction. External fixation also carries the risk of pin tract infection.[2,7,8] Open reduction and internal fixation with dorsal or volar plates requires sufficient exposure of the fracture site to facilitate direct visualization, accurate reduction, and secure plating fixation. Common critiques of this procedure include: wide soft tissue dissection; tendon complications, including tenosynovitis or tendon rupture; and prominent hardware associated with the internal fixation plate. Many patients need to undergo additional surgery to remove the implant.[9–13]

The use of IM nails for fixation of the distal radius is intended to minimize complications associated with the treatment of unstable distal radius fractures. IM nail fixation serves as an internal splint and provides mechanical advantages by increasing fracture stability, transfer of loads across the fracture, and maintenance of alignment to promote bone healing.[14] IM fixation of forearm fractures is reported to result in early union through increased stability, preserved periosteal circulation, and minimally invasive surgery with less blood loss.[15] The advantages of Micronails for distal radius fractures include load sharing, fixed-angle divergent screws for subchondral bone support, and minimal surgical dissection. Other potential benefits of intramedullary fixation include accelerated fracture healing by preservation of periosteal vascularity and provision of internal bone grafting by intramedullary broaches. There was no additional bone grafting in any of our study patients.[14] Rapid resumption of hand/wrist activities with minimal complications increases the clinical benefits of this procedure.

Complications and pitfalls during surgery relate mainly to improper nail size and reaming technique. Other possible complications of IM nail fixation may include dorsal superficial radial sensory nerve injury, soft tissue irritation from screw heads, and screw penetration into articular surfaces.[16,17] These complications are uncommon, and we did not observe any of them in this study. To avoid unintended articular screw penetration, using fluoroscopic assistance routinely during screw placement is needed. Although four patients had temporary numbness along the dorsal side of injured wrist, all symptoms were mild and resolved shortly after surgery. Normally, the superficial radial sensory nerve is within or close to the surgical field, and is therefore highly susceptible to damage from surgical instruments. We recommend that the superficial radial sensory nerve should be identified and protected throughout the surgical procedure.

The average normal distal radius radiographic parameters are as follows: 11.6 mm radial height, 23.6° radial inclination, and 11.2° volar tilt.[18] Acceptable distal radius radiographic parameters are as follows: no more than 2 mm shortening relative to ulnar head, no less than 10° radial inclination, and neutral volar tilt.[19] All postoperative radiographic parameters were restored to within normal range for the patients in this study, except for volar tilt. Postoperative volar tilt was $0 \pm 5°$. The slight dorsal tilting that occurred in five of our cases after nailing is probably due to the straight design of the implant in the sagittal plane. Both Brooks et al and Ilyas reported that the Micronail restored all parameters to normal except for volar tilt, which was neutral or slightly dorsal in their study patients after treatment.[16,17]

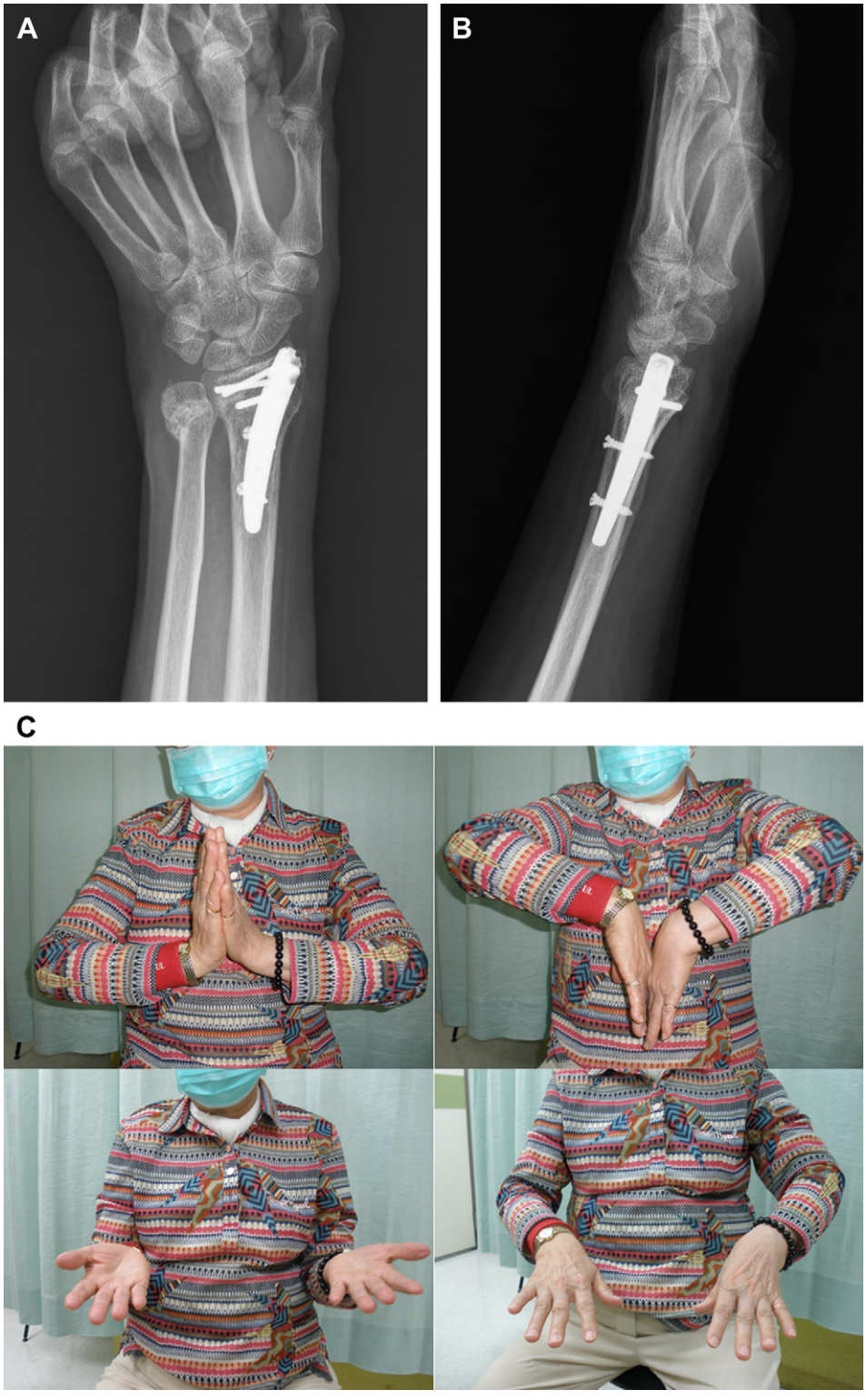

Fig. 2. Postoperative radiographs of a 73-year-old woman (Case 1) with AO Type A3 distal radius fracture with ulnar head fracture. (A) Postero-anterior projection showing Micronail fixation and osseous union at 3 months, (B) lateral projection at 3 months, and (C) photographs at 1-year follow-up showing satisfactory functional results.

In this study, the mean postoperative modified Mayo wrist score was 84.5 (range 65–100), which is comparable to the results of both Brooks et al and Ilyas.[16,17] Four patients in our study had fair results. All of these patients had a treatment delay of more than 6 weeks. Although Micronail is not contraindicated in cases with delayed management, the inferior outcome of these cases can be attributed to the soft tissue contracture and wrist stiffness after prolonged immobilization that delay fracture healing after corrective osteotomy.[20]

The limitations of this study include the small sample size and short follow-up period. Larger outcome studies with direct comparisons between IM nails and other osteosynthesis techniques

Table 3
Preoperative and postoperative radiographic parameters and Mayo score after intramedullary device fixation in 12 patients with distal radius fractures.

Patient no.	Preoperative			Postoperative			
	Radial height (mm)	Radial inclination (degrees)	Volar tilt (degrees)	Radial height (mm)	Radial inclination (degrees)	Volar tilt (degrees)	Mayo score
1	7	13	−18	8	18	6	80
2	6	14	−22	9	16	4	100
3	10	18	−15	12	24	−5	65
4	9	10	−4	10	19	1	90
5	1	2	3	11	20	−6	70
6	7	13	−22	10	20	2	100
7	10	24	5	11	22	6	95
8	9	22	4	10	20	2	95
9	11	22	−30	12	23	−8	85
10	6	15	19	9	22	−2	70
11	5	11	−2	9	20	−8	70
12	10	19	19	11	21	6	90
Mean	8 ± 3 mm	15 ± 6°	−5 ± 16°	10 ± 1 mm	20 ± 2°	0 ± 5°	84.2 ± 12.7

that include longer follow-up are necessary to evaluate the cost effectiveness and long-term efficacy of IM nail fixation in extra-articular distal radius fractures.

5. Conclusion

IM nail fixation for extra-articular distal radius fractures is a less invasive technique than alternative forms of pin fixation, and can provide satisfactory fracture realignment and secure fixation. Surgical osteosynthesis using Micronail without bone grafting is a feasible and effective option yielding encouraging radiographic and functional outcomes.

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