Original Article

Distal radius fractures: Minimally invasive plate osteosynthesis with dorsal bicolumnar locking plates fixation

Alvin Chao-Yu Chen, Ying-Chao Chou, Chun-Ying Cheng

Abstract

Background: Controversy still exists regarding the current treatment modalities for unstable distal radius fractures. There are yet few articles investigating the efficacy of bicolumnar dorsal plating technique, which is designed to minimize tissue dissection while providing sufficiently secure fixation. A clinical study was performed to evaluate the feasibility of the minimally invasive plate osteosynthesis (MIPO) technique using a modified dorsal approach for the treatment of distal radius fractures.

Materials and Methods: Thirty patients with unilateral distal radius fracture who underwent bicolumnar plate fixation with a minimally invasive dorsal approach between September 2008 and December 2010 were included in this retrospective study. Twenty four patients (8 men and 16 women) with a mean age of 53 years (range 18-85 years) were available for followup of at least 1 year or more were included in final study. Herein, we report the functional radiological outcomes of the study. There were three cases of AO Type A fracture, five cases of AO Type B fracture, and 16 cases of AO Type C fracture.

Results: The union was achieved in all the patients. The functional results at one-year followup, assessed using the modified Gartland and Werley scoring system, were excellent in 14 patients, good in seven patients, and fair in three patients. The average correction of deformity was 4.1 mm for radial height, 7.6° for radial inclination, and 20.7° for volar tilt.

Conclusions: MIPO with a dorsal approach is a feasible option for the management of displaced distal radius fractures and can result in favorable surgical outcomes.

Key words: Bicolumnar fixation, distal radius fracture, dorsal approach, minimally invasive osteosynthesis
MeSH terms: Wrist injuries, radius fracture, minimally invasive surgical procedures, fracture fixation, bone plates

Introduction

Unstable distal radius fractures requiring surgery have long been treated with diverse techniques including pinning, external fixation, nailing, and plating.[1,2] Open reduction and internal fixation with locking distal radius plates have become very popular over the last 10 years.[3-5] However, controversy still exists regarding the complications associated with current implants and fracture patterns that are not amenable to those surgical techniques.[6-8] Low-profile dorsal plates were developed to address these problems by providing bicolumnar fixation and minimizing extensor tendon complications.[9,10] To date, few studies have described the effectiveness of or the complications associated with minimally invasive plate osteosynthesis (MIPO) techniques using these new implants.[11] We studied the radiographic and functional outcomes of bicolumnar plating osteosynthesis through a minimally invasive dorsal approach in unstable distal radius fractures.

Materials and Methods

Thirty patients with unilateral distal radius fracture who

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underwent bicolumnar plate fixation with a minimally invasive dorsal approach between September 2008 and December 2010 were included in this retrospective study. In the end, 24 of 30 patients underwent clinical followup at 1 year or more were finally included in study [Table 1]. There were 8 men and 16 women, with an average age of 53 years (range 18–85 years). There were 6 dominant hands and 18 nondominant hands with fractures. Ten fractures were attributed to a simple ground fall and 14 fractures were due to either a fall from more than standing height or a traffic collision; two were work-related fractures.

This study was approved by our Institutional Review Board. The eligibility criteria were dorsally unstable fracture of the distal part of the radius [Figure 1]. Fracture patterns were categorized according to the Müller-AO comprehensive classification[12] and were confirmed by an independent orthopedic specialist. Fractures of AO Type A1 and B3 were intentionally excluded from our study since neither of these fracture patterns indicated dorsal plating fixation. According to the AO classification, 3 of the fractures were Type A, 5 were Type B, and 16 were Type C. The Type C fractures included 9 C1 fractures, 5 C2 fractures, and 2 C3 fractures. The operative procedure was performed within 1 week of injury. The average time interval between injury and surgery was 2 days (range 1–6 days).

We used the Gartland and Werley scoring system[13] for assessment of functional outcome with modification based on Sarmiento *et al.*'s criteria of the minimum in range of motion (ROM) for normal function, which consisted of extension (45°), flexion (30°), radial deviation (15°), ulnar

Figure 1: Radiographs of the wrist joint anteroposterior and lateral views of an 18-year-old male showing a dorsally displaced, AO Type C1 fracture of the distal radius with displaced fracture of the ulnar styloid

Table 1: Patient demographics and fracture data

Case number	Sex	Age (In years)	Wrist	Fracture type†	Injury‡	Time to surgery§	Followup (In months)
1	Female	84	Left	B2	S	3	36
2	Male	18	Left	B2	H	1	24
3	Male	48	Left	B2	H	1	28
4	Female	85	Right	C2	S	1	30
5	Female	48	Left	C1	H	2	26
6	Male	55	Right	C1	H	6	38
7	Female	70	Right	C1	S	4	36
8	Female	60	Right	C2	H	1	30
9	Female	63	Left	C3	H	1	24
10	Female	51	Left	A3	S	1	20
11	Male	24	Left	C1	H	1	18
12	Female	53	Left	C3	H	1	32
13	Female	66	Left	C1	S	1	17
14	Male	47	Left	C2	H	4	20
15	Female	22	Left	C2	H	1	12
16	Male	59	Left	C1	S	6	24
17	Female	18	Left	C1	H	1	27
18	Female	72	Left	B2	S	1	12
19	Female	60	Left	A3	S	1	15
20	Male	68	Left	C1	H	1	48
21	Male	22	Right	C2	H	2	36
22	Female	82	Right	C1	S	2	20
23	Female	62	Right	A3	S	1	12
24	Female	39	Left	B2	H	2	13

†Fracture type=Based on the Müller-AO comprehensive classification,[12] ‡Injury - Injury mechanism: S (due to a simple ground fall) or H (due to a fall from more than standing height or traffic collision), §Time to surgery=Days

deviation (15°), pronation (50°), and supination (50°).[14] Standard preoperative and postoperative posteroanterior and lateral wrist radiographs were obtained for each patient. We recorded radiographic parameters from the electronic images (Centricity Enterprise Web 3.0; GE Medical Systems, Paris, France) such as the degree of volar angulation, radial inclination (RI) angle, and radial height (RH) [Figure 2]. Routine followup radiographs were taken in the clinic at 6 weeks, 3 months, and 1 year after surgery. Statistical analysis with a two-sample *t*-test was used to determine the significance of differences in radiographic parameters between postoperative radiographs and those of the 1-year followup. A significant difference was defined as a $P < 0.05$.

Operative procedure

All operations were performed by the single surgeon (Chen, AC-Y). Under general anesthesia, distal radius fractures were reduced and fixed temporarily by Kirschner-wire (K-wire) after realignment was confirmed using a mini C-arm image intensifier. Two K-wires were used to secure the dorsal lunate facet fragment for correction of dorsal angulation. Another two were used to fix the radial styloid fragment for maintenance of RH. A 1 cm skin incision was made distal to the fracture side along the intermediate column and was directly deepened to enter the fourth compartment. The extensor tendons were then protected and retracted toward the ulna to explore the dorsal lunate fragment. Blunt dissection was performed using a freer elevator underneath the extensor tendons until it met the second incision proximal to the fracture site. The extensor retinaculum was partially released in the distal half, and the dorsal locking plate (Synthes Ltd., Paoli, PA, USA) was inserted along the ulnar border of the distal radius. In most cases, the dorsal locking plate was precontoured at the distal end to allow caudocephalic placement of locking screws in the subchondral area of the distal fragment. Another two screws were used to fix the proximal part of the fracture. A third skin incision was then made on the radial styloid. The radial sensory nerve was identified and protected. An anatomical radial locking plate (Synthes Ltd., Paoli, PA, USA) was inserted subcutaneously along the interval between the first and second compartments. The radial styloid fragment was fixed with one or two locking screws, and the plate was secured with two screws through another incision proximally [Figure 3]. For intraarticular fractures involving the scaphoid or lunate fossa, dorsal capsulotomy was performed through the same incision to allow direct visualization and facilitate restoration of articular congruity. K-wire was used as a joystick to mobilize the articular fragment [Figure 4]. In cases with metaphyseal comminution, injectable bone graft substitutes were used through an 11-gauge spinal needle to fill the osseous defect. The wound was approximated with subcuticular sutures and dressed well. A light short arm splint was applied on the volar side for 1–2 weeks.

Results

Radiographic analysis of preoperative, postoperative, and 1-year radiographs was performed. All patients showed

Figure 2: Radiographic parameters were measured from the electronic images including radial inclination (RI) angle, radial height (RH) and volar tilt (VT) angle

Figure 3: Radiographs anteroposterior and lateral views of distal forearm and wrist taken 3 months after operation showing bicolumnar plate fixation for the distal radius, suture anchor fixation for the ulnar styloid, and osseous union

radiographic union after surgical management. According to the radiographic analysis, all the anatomical parameters were efficiently restored and maintained. The average final correction of deformity was 4.1 mm (range 0–9 mm) for RH, 7.6° (range 0–18°) for RI, and 20.7° (range 5–39°) for volar tilt (VT) [Table 2]. No significant differences were found between postoperative and final RH, RI, and VT ($P > 0.05$). The ROM of the wrist compared to the other side at 1 year followup averaged 85% of extension, 75% of flexion, 83% of radial deviation, 85% of ulnar deviation, 93% of pronation, and 85% of supination [Table 3]. Grip strength measured using an electronic dynamometer (TKK 5401; Takei Scientific Instruments Co., Ltd., Niigata, Japan) was restored to 83% (range 65–100%) of the other hand at the final followup evaluation. Functional scores, according to the Gartland and Werley scoring system, were 3.7 ± 3.6 (range 0–12); there were 14 excellent, 7 good, and 3 fair results.

Three of 24 patients (13%) had surgical complications: One was osseous and two were soft tissue related. There was one case with screw loosening. This occurred in an elderly and very osteoporotic patient of AO Type C2 fracture with metaphyseal comminution. Progressive VT and loss of RH with loose proximal screws were noted after 3 months of followup. This patient acquired osseous union with pain-free motion of the wrist at 6 months. As for soft tissue complications, there were no wound infections or extensor tendon ruptures. Two patients complained of extensor tendon irritation. Only one of them asked us to remove all the implants. Another patient asked us to remove the radial styloid locking plate because of an uncomfortable sensation when the patient played volleyball.

Figure 4: Peroperative arthroscopic views showing Kirschner-wire was used as a joystick to mobilize the articular fragment. Joint congruence was confirmed by C-arm image intensifier

Discussion

Traditionally, the dorsal approach in the distal radius may have some shortcomings including wide dissection, excursion of tendons after rerouting (especially the extensor pollicis longus), and tendon attrition caused by the dorsal implants.[15,16] A modified dorsal approach with separate incisions was designed to alleviate the above complications, and it proved to be an efficacious option for managing distal radius fractures with limited complications.[17]

In our series, good or excellent results were achieved in 21 of 24 patients. In the remaining three patients with fair results, one had proximal screw loosening and delayed union until 6 months. The other two patients had implant-related soft tissue complications. All patients were satisfied with their final results. The overall outcomes were comparable to those of other studies that used conventional open and mini-open procedures.[6,18,19]

In a successful MIPO surgery, the quality of indirect reduction and fixation stability should not be compromised by smaller skin incisions and less exposure. We performed radiographic analysis in our series; RH, RI, and VT were all perfect. In addition, there were no significant differences between postoperative and 1-year radiographic parameters, confirming that fixation was adequately secured to maintain realignment until osseous healing.[20]

Table 2: Radiographic data

Radiographic parameters	Radial height*	Radial inclination†	Volar tilt‡
Preoperative	7.0±4.6 (0-15)	13.8±8.3 (0-24)	−19.4±14.6 (−40-24)
Postoperative	10.3±2.3 (5-15)	20.1±3.9 (10-26)	0.4±8.1 (−15-13)
Final§	10.1±2.9 (4-16)	20.0±4.5 (9-27)	0.3±7.5 (−11-13)
Correction‖	4.1±3.0 (0-9)	7.6±6.0 (0-18)	20.7±11.6 (5-39)
*P***	0.164	0.357	0.448

*Radial height, mm, †Radial inclination, degree (°), ‡Volar tilt, degrees (°); negative values indicate dorsal tilting, §Final, final radiographic survey at 1 year after surgery, ‖Correction was measured according to the difference between the postoperative and final radiographs, **The *P* value indicated the statistical difference between the postoperative and final radiographic parameters

Table 3: Range of motion and grip strength

ROM variable	Mean° (%*)	SD† (°)	Range (°)
Extension	54.2 (85)	13.2	25-80
Flexion	51.5 (75)	12.2	25-75
Radial deviation	15.3 (83)	5.3	10-20
Ulnar deviation	25.3 (85)	6.8	15-35
Pronation	71.2 (93)	11.9	65-85
Supination	74.8 (85)	12.3	60-90
Grip strength (kg)	21.8 (83)	10.3	10-34

*Compared with contralateral side, †SD=Standard deviation, ROM=Range of motion

Moreover, general concerns regarding soft tissue complication after dorsal plating in the distal radius could thus be lessened by minimizing tissue dissection through separate skin incisions.

Although MIPO techniques for distal radius fractures have also been successfully performed through a volar approach by preserving the pronator quadratus muscle,[5,21] they may require either downsized implants or shifting to transverse skin incision distally to fit the minimal exposure involved in such techniques. A recent study compared the traditional volar approach with a volar MIPO approach.[22] The clinical and radiographic results were not statistically different although patient's satisfaction was higher and pain score was lower in the MIPO group. However, neurovascular complications were concerned with MIPO through volar approach. Whereas dorsal approach allows a direct and quick access to the distal radius. In index surgery, MIPO techniques have been introduced through a modified dorsal approach using metal implants that are commonly used in conventional osteosynthesis procedures. Additional surgical procedures, for example, bone grafting or open reduction of articular fragment, can also be introduced through the same skin incision over the dorsal wrist when necessary.[20]

Several limitations of this study were noted. First, it is a retrospective study with relatively high number of patients (six patients, 20%) lost at the followup. Second, there is a lack of a control group. Third, the sample size is small with short term followup period. Further prospective and larger outcome studies with direct comparison to other osteosynthesis techniques are necessary to better evaluate the long term effect and superior efficacy of the dorsal MIPO technique.

Conclusions

The clinical results of a modified dorsal approach for distal radius fracture achieved in the current study were encouraging. Bicolumnar double plating could provide sufficiently secure fixation and yield a low rate of complications. Both functional survey and radiographic analysis confirmed that the index procedure is a feasible option for the management of dorsally unstable distal radius fractures and can result in favorable surgical outcomes.

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Conflicts of interest

There are no conflicts of interest.

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