Minimally Invasive Surgical Fixation for Unstable Fractures of the Distal End Radius in Adults

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Abstract:

Introduction: There has been a significant change in treating distal radius fractures in the past twenty years. Surgeons can now guarantee satisfactory outcomes for these disabling fractures because techniques and hardware have advanced to such an extent. Mini-invasive surgery is currently popular due to technical and physiological reasons and obvious aesthetic considerations. The anterior Henry approach is the gold standard for fixing distal radius fractures because anterior locking plates are widely used. However, it has drawbacks, such as the size of the incision.

Patients and Methods: Using a T-shaped palmar locking plate or 2.4mm LCP buttress plate-volar, patients undergoing treatment of distal radial fractures using the modified MIPO approach are included in a prospective clinical case series, including all patients who met the inclusion criteria that were managed by MIPO one year from the start of the study. (October 2022 to September 2023) 24 cases.

Results: Minimal invasive techniques have many advantages, such as minimizing the risk of iatrogenic injury to the palmar branch of the median nerve, improved appearance with minimal scar, reduced incisional complications, and preservation of PQ function, which is beneficial for functional tasks.

Discussion: Minimally invasive volar plating of distal radial fractures is a safe and effective procedure with good functional results, early recovery time, preservation of pronation function, and better cosmetic appearance, so it will gain more popularity.

Keywords: Distal radius fractures; Minimal invasive fixation; Poronator quadratus sparing.

Introduction:

Over the past twenty years, there has been a significant change in managing distal radius fractures. With these disabling fractures, surgical techniques and hardware have evolved to the point where the surgeon can typically ensure favorable outcomes (1). Because anterior locking plates are widely used for fixing distal radius fractures, the anterior Henry method is increasingly considered the gold standard. It reduces complications, particularly type I complex regional pain syndrome (CRPS), lowers the risk of nonunion, and permits early wrist mobilization (2). However, there are certain drawbacks, including the unpleasant size of the incision and the loss of ligamentotaxis brought on by the articular bone fragments' detachment from their muscle, ligament, and capsule attachments. For this reason, the authors have created a minimally invasive procedure (3). Mini-invasive surgery is currently popular across every field of surgery for technical and physiological reasons, in addition to the apparent aesthetic concerns. A limited approach has been demonstrated to preserve the distal radius and carpus ligament and muscle attachments, enabling ligamentotaxis to reduce fractures (4). A limited approach prevents nonunion, which is seen in cases of extensive approach with periosteal stripping in patients with

comorbidities, as well as ischemia and necrosis of the small articular fracture fragments (5). Lastly, a limited approach encourages consolidation by maintaining the fracture hematoma (6).

Materials and Procedures:

Study Type:

Patients receiving the modified MIPO approach for treating distal radial fractures with a volar T-shaped palmar locking plate or 2.4mm LCP buttress plate are included in a prospective clinical case series. It was carried out in the Trauma Unit of the Assiut-University Hospital's Orthopaedics and Traumatology Department from October 2022 to September 2023. The study protocol was approved by the Institutional Review Board of the Faculty of Medicine, Assiut University (IRB no: 17101582).

Research Subjects:

Inclusion Criteria:

1. Patients with unstable distal radial fractures, according to AO's classification of distal radial fractures (types A2, A3, B1, B2, B3, etc.), are accepted for inclusion.
2. 2. Maturity of the skeletal patients of both sexes in the age range of 18 to 80 years.
3. 3. Acute fractures, which occur three weeks after injury.

Exclusion Criteria:

1. All open fractures that are infected.
2. Fractures associated with vascular injury that need to be repaired, as well as suspected pathologic fractures, ruptured tendons, or soft tissue loss.

We calculated the sample size by considering all patients managed by MIPO who met the inclusion criteria within a year of the study's start (September 2022 to October 2023). Radiological evaluations were the distal radius's lateral and anteroposterior plain X-rays**, and** CT for the Evaluation of Fracture Patterns for Articular Fracture Extension.

Procedure:

The patient underwent either regional or general anesthesia and was placed in a supine position on a standard table. Under fluoroscopy, the manual reduction was carried out. After achieving a suitable reduction, one or two 1.5 mm Kirschner wires were obliquely inserted to maintain the reduction from the styloid process of the radius to the proximal ulnar side; sometimes, the wires were put in the other direction as well. An additional K wire must be added for a type C fracture parallel to the distal radius articular surfaces.

The surgical approach:

Double longitudinal incision

Patients with distal radius articular surface and fracture site were separated by less than 1 centimeter and were given two 2 cm skin incisions each. In addition to the proximal skin incision, make a distal incision parallel to the flexor carpi radialis if the distance is greater than 1 cm. The flexor carpi radialis and the radial artery were retracted to the radial or ulnar side following the radial side's superficial and deep fascia incision. The pronator quadratus was made visible by retracting the flexor pollicis longus to the ulnar side. The incision should be done on the fracture end in a few patients with an unsatisfactory closed reduction to help reduce the risk under direct vision. An appropriate locking plate, oblique in shape, was placed extraperiosteally through the incision. On the radial side of the flexor carpi radialis, a 2 cm proximal skin incision was made following successful fracture reduction. The flexor pollicis longus was dissected with forceps to expose the proximal end of the locking plate, and the superficial and deep fascia were cut to retract the radial artery. The incisions were closed in layers.

Single longitudinal incision

A longitudinal incision of 3 cm is made in the skin, starting from the location of the proximal wrist crease, which is 2 cm below. Next, a longitudinal incision of the same length is performed on the forearm fascia; then, the FPL and radial arteries are separated. Distal dissection is used to find the watershed line, visualizing the articular surface and palmar radiocarpal ligaments. The anatomical locking volar plate for the

distal radius plate is inserted, and the screws are placed through proximal and distal ports. The single incision enables the use of the skin's elasticity. A portion of the PQ may be longitudinally dissected to aid in the reduction.

Fixation plate type:

T or 2.4 plates may be utilized; the plates selected will depend on the fracture pattern.

Closure: 2/0 Vicryl Rapid was used to stitch the skin incision.

Postoperative care:

None of the patients received plaster splints after surgery. Two or three days following the procedure, we advised the patients to perform exercises for their elbows, shoulders, metacarpophalangeal joints, and interphalangeal joints. After three to five days following surgery, patients were instructed to move the affected wrist joints in extension and flexion. Active rotational forearm exercises were also added two weeks after surgery.

Further follow-up:

Two-week postoperative visits will be made to observe wound healing and range of motion, and six weeks will be used to assess bone healing by lateral and anteroposterior radiographs and clinical evaluation. Then, regularly every two months till the end of the six months. The last visit is scheduled after six months to assess functionality and identify any problems. Utilizing the Mayo wrist score and Quick DASH score for functional evaluation and full active motion of the wrist joint and DRUJ (flexion, extension, pronation, supination, radial tilt, and ulnar tilt). Hand grip strength, union by plain radiography, and VAS score are used to evaluate pain.

Primary (main) measures for research results: The Mayo wrist score and radiographic and clinical bone union are used to determine wrist function. Secondary: Utilizing a VAS score to evaluate discomfort, the Goniometer's active range of motion, hand grip strength was assessed using a dynamometer, and upper limb impairment was assessed using the Quick DASH score. Difficulties include early-stage concerns such as delayed wound healing, tourniquet palsy, and late complications: 1. FPL rupture. 2. Pain in the arthrocarpal region. 3.

Malunion/nonunion. 4. Complex Regional pain syndrome. 5. Unusual scar.

Results:

All patients who met the inclusion criteria and were under MIPO's management after a year were included in the current prospective case series study (from September 2023 to October 2022). Three of the cases had been scheduled for MIPO. Still, due to challenging intraoperative reduction, they were shifted to the standard technique and are therefore not included in the current study. Two of the 26 instances in the analysis were lost to follow-up, leaving 24 cases.

Table 1: Characteristics of presented cases:

Category	Total
Age (years)	Average 46.54 ± 13.67
Sex	
Male	21 (87.5%)
Female	3 (12.5 %)
Dominant Hand	
Right	23 (95.8%)
Left	1 (4.2%)
Comorbidity	
DM	2 (8.3%)
HTN	5 (20.8%)

Data is expressed as frequency (percentage) and mean (SD).

The study's mean age was 46.54 ± 13.67 years, as reported. According to sex, there were 21 cases (87.5% of which were male), 23 of which were right-handed, and one left-handed. Five cases had hypertension, and two had diabetes.

Table 2: Characteristics of the injury:

Category	No. (percentage)
Side affected	
Right	14 (58.3%)
Left	10 (41.7%)
Dominant Hand affected	15 (62.5%)
AO classification	
A2	4 (16.7%)
A3	2 (8.3%)
B1	5 (20.8%)
B2	2 (8.3%)
B3	4 (16.7%)
C1	5 (20.8%)
C2	2 (8.3%)
Time from Injury to Surgery (days)	Average 3 (1-5)

Table 3: Operative Details:

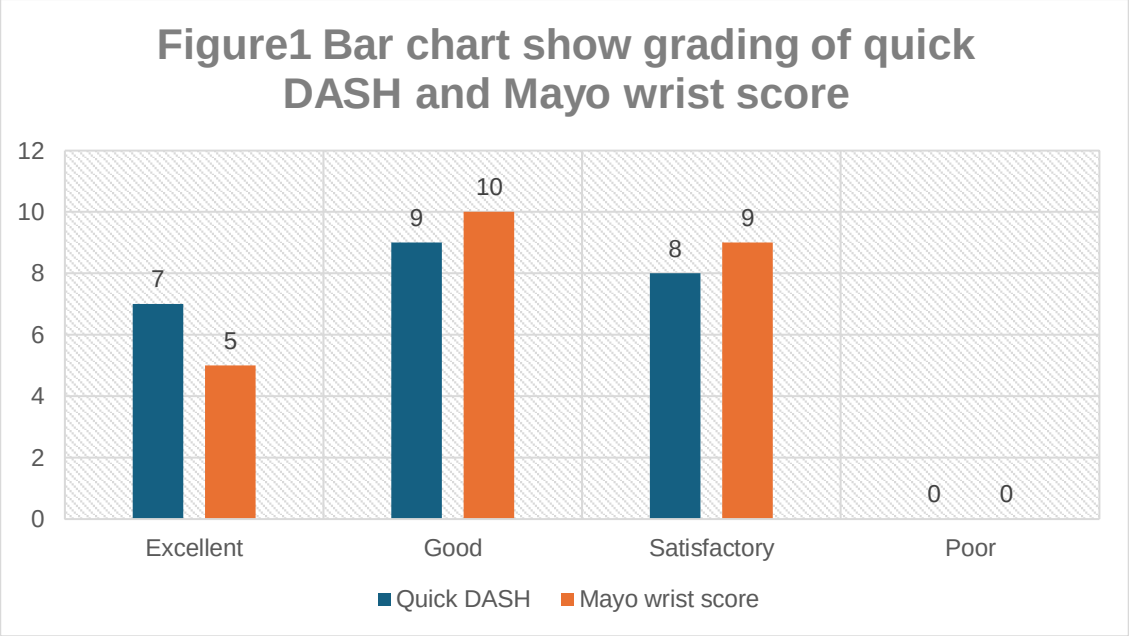
Category	Average vs No. (percentage)
Incision size (cm)	**Average 2.7 (1.5 – 5)**
Incision numbers	
Single incision	16 (66.7%)
Double incision	8 (33.3%)
Type of plate used	
I. T plate	12 (50%)
II. 2.4 plate	12 (50%)
Operative time (minutes)	57.29 (40-75)

Table 4: Results of the Study:

Category	Average
Active ROM	
Flexion	77.5 (60-85)
Extension	73.75 (65-80)
Pronation	76.67 (65-85)
Supination	80.5 (75-90)
Radial tilt	23.13 (15-30)
Ulnar tilt	13.33 (10-15)
VAS score	1.38 (1-2)
No pain	Zero
Mild pain	24 (100%)
Moderate pain	Zero
Severe pain	Zero
Quick DASH score	14.38 (4.5-35)
Excellent	7 (29.2%)
Good	9 (37.5%)
Satisfactory	8 (33.3%)
Poor	Zero
Mayo wrist score	78.96 (60-90)
Excellent	5 (20.8%)
Good	10 (41.7%)
Satisfactory	9 (37.5%)
Poor	Zero

Table 4: Results of the Study ***(Cont.)***

Category	Average
Hand grip	54.64 (44-64)
Excellent	5 (20.8%)
Very Good	6 (25%)
Above average	7 (29.2%)
Average	5 (20.8%)
Below average	1 (4.2%)
Union	24 cases 100%
Complications	
Thenar paresthesia	1 (4.2%)
Delayed healing	1 (4.2%)
Tourniquet palsy	1 (4.2%)



Discussion:

Distal radius fractures are the most common fractures in the upper limb, accounting for 17% of fractures in patients who enter the emergency room (7, 8), with an incidence of two fractures per 1,000 individuals annually (9). Several treatment options have been suggested for managing distal radius fractures, including percutaneous pinning, internal fixation, external fixation, closed reduction, casting, and combinations of these techniques. The need for surgical treatment of distal radius fractures has increased since nonsurgical treatment frequently delays the patient's return to daily activities (7, 9, 10,11). Complex regional pain syndromes, pin-track infections, digital stiffness, and poor functional results might arise from prolonged wrist immobility after external fixation (12).

Anatomic reduction of the fractured distal radius bone becomes possible by open reduction and internal fixation (7) using a volar locking plate, which also promotes an early return to the pre-fracture functional level. Abnormal reduction of the fractured wrist joint causes pain, instability, and impingement syndrome, in addition to reducing grip strength and range of motion (ROM) (9). The classic Volar Henry procedure, which includes making an L-shaped incision in the PQ muscle and securing the Volar locking plates, is used in clinical settings. However, there were certain disadvantages, such as the need to cut the pronator quadratus muscle and separate the periosteum of the fractured region, which

reduced the pronator's strength and durability (13). Healing may be delayed if there is devascularization of the fracture fragments due to significant soft tissue separation over the bone. There are a few known side effects, such as infections, problems involving soft tissues, complications involving the nervous system, problems involving the bones, and complex regional pain syndrome (7). The development of biological defense mechanisms against these side effects is currently receiving increasing interest. One such method is minimally invasive plate osteosynthesis (MIPO) with limited dissection. Two main advantages of MIPO are less soft tissue injury and preservation of periosteal circulation in the broken bone. When fracture fragments with delayed healing retain their soft tissue and vascularity, surgeons might expect better clinical outcomes and faster healing (9). MIPO is used to manage distal radius fractures, which involve smaller incisions and preserving the pronator quadratus. This allows patients to regain their grip strength more rapidly following surgery and report minimal pain around the incisions. The rotational motion remained almost unchanged (7, 8).

Table 5: A comparison between the current study and previous studies that were done by a minimally invasive technique

	The current study	Zenke study(14)	Tobe study(10)	Zhang study(8, 9)	Paul Vernet study(15),	Gian van study(16)	Chen study(3)	Emilie Pire study(17)
No of cases	24	30	35	83	710	25	21	15
Average age	46.54 ± 13.67	62.1 ± 15.6	58	42 (18-67)	58	42.8		55.7
Sex M/F	21/3	10/20		49/34	198/512	16/9	7/14	9/6
Rt/lt	23/1	12/18				12/13		
Classification	A1 4.2 % A2 (12.5%) A3 (8.3%) B1 (20.8%) B2 (8.3%) B3 (16.7%) C1 (20.8%) C2 (8.3%)	OTA classification (23-): A2/A3/C1/C2 7/10/5/8	14 A2 10 A3 7 C1 4C2	A2 28% A3 34% B3 8% C1 17% C2 13%		A 8 (32%) B 11 (44%) C 6 (24%)		A2 (3 20%) A3 (8 53%) C1 1 6.6% C2 1 6.6% C3 2 13.3%
The mean period from injury to surgery (days)	3	2.5 ± 2.6				2.8		
Operative time	57.29	61 ± 18.9			41 min (range, 11-120 min)		60 ± 13	58.4
Minimum follow-up	6 months	12 months	6 months			12 months	12 m.	
Mayo wrist score	78.96						95 ± 5.94	
VAS score	1.38	0.4 ± 0.6 range, 0–4.0		4.66 pain scar	1.13/10	1.29		1.5/10
Quick DASH	14.38	4.2 ± 6.8 DASH		3.4 ± 3.5 DASH	13.28	8.6 DASH		22.8
Hand grip	54.64	To opposite one 94.2 ± 12.8		96.2 ± 3.3	79.68%	Opposite 96.6%		65.4%
Active ROM	Flex. 77.5 Ext. 73.75 Pronation 76.67 Supination 80.5	67.2 ±6.7/86.5 ± 6.7 Ext+flex 88.9 6 3.2/88.6 ± 4.3 Pronation / supination	Flex 72.6 Ext 66.8 Sup 82.2 Pron. 82.2	(°):Flex. 72.8 ± 14.7; Ext. 67.3 ± 9.6;Sup. 84.9±10.8; Pro. 82.6 ± 12.2	flexion was 87.23%, extension 88.52%, pronation 96.17%, supination 93.41%,	Ext+flex to opposite 90.7 Pronation supinati on 96.8		Flex. 82.87% Ext. 81.93% Pronation. 95.87% Supination 81.2%
Complications:	1 tourniquet palsy 1 thenar paresthesia 1 delayed wound healing	1 case 3.3 plate protrudes into a joint			16 cases of secondary Displacement 2%, with 4 revision procedures 0.5%, 1 of sepsis at 6 months 0.1%, 10 of complex regional pain syndrome 1.4%, and 14 of median nerve paresthesia 1.9%, with 4 carpal tunnel release 0.5% procedures			One extensor pollicis longus rupture treated by tendon transfer

Distal radial fractures of types A2, A3, B3, C1, and C2 (AO/OTA classification) are commonly treated with volar plating (8). However, type C3 fractures cannot be treated with a small incision. Many benefits accompany minimally invasive procedures, such as decreased risk of iatrogenic injury to the median nerve's palmar branch, less scarring, fewer incisional problems, and preservation of PQ function. (8) PQ has been shown to have two distinct heads. The superficial head is the main mover in forearm pronation, whereas the deep head stabilizes the distal radioulnar joint dynamically. The pronator quadratus expands by about 1 cm during maximal pronation and supination. Minimally invasive surgery is preferable because adhesion surrounding the muscle may eventually occur when the pronator quadratus muscle is separated longitudinally in the conventional procedure (75). PQ preservation is important for practical tasks like utilizing a screwdriver or a doorknob. (8)

Our longitudinal short incision is easily converted from the traditional method. (8) Additionally, when sliding the plate under PQ and into touch with the radius bone, surgeons need to be careful not to let the

flexor tendons or median nerve get in the way of the plate and bone. MIPO is becoming increasingly recommended in cases of distal radius fractures. (17) All distal fracture types classified by the AO were included in this study, except for type C, which is too hard to treat with a tiny incision. (10)

Study limitations:

1. There isn't a reference group available.
2. The procedures and evaluations were completed at various times, and as surgeons' experience increased over time, it might impact determining the techniques' outcomes.
3. No comparison.

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