Long Volar Plating for Metadiaphyseal Fractures of Distal Radius: Study Comparing Minimally Invasive Plate Osteosynthesis versus Conventional Approach

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Abstract

Background Minimally invasive plate osteosynthesis (MIPO) has been used in wrist surgery for several years. The purpose of this retrospective study was to compare clinical and radiologic outcomes of MIPO technique with those of a conventional approach in the treatment of metadiaphyseal distal radius fracture by long volar plating.

Materials and Methods Our series consisted of 32 fractures in 31 patients, mean age 63.9 years, including 16 men and 15 women. MIPO technique was used in 15 wrists (group 1) and conventional approach (> 60 mm of skin incision) in 17 wrists (group 2). In group 1, a long volar plate was inserted under pronator quadratus through a 15- to 30-mm distal incision then fixed to the epiphysis of the distal radius. Then, through a 15- to 30-mm proximal incision, the plate was fixed to the diaphysis of the radius, thus reducing the fracture.

Results In group 1, mean distal incision size was 23.5 and 16.9 mm for proximal one. Mean total scar size (sum of both distal and proximal incisions) was 40.0 mm in group 1 and 84.1 mm in group 2. Mean tourniquet time was 58.4 minutes in group 1 and 68.9 minutes in group 2. At latest follow-up, no significant difference was noted in both the groups concerning pain, quick-DASH score, grip strength, ROM, and radiologic data. One extensor pollicis longus rupture treated by tendon transfer was done in group 1.

Conclusion The MIPO technique for metadiaphyseal fractures of the distal radius by long volar plating has cosmetic and economic advantages compared with the conventional approach. Conversion to conventional approach is possible at any time in case of technical difficulties.

Level of Evidence III.

Keywords

- fractures
- minimally invasive plate osteosynthesis
- distal radius
- mini-invasive
- long plate
- metadiaphyseal fracture

Plate fixation using a minimal approach has been increasingly used to fix fractures in the last two decades in the hip,¹ knee,^{2,3} ankle,⁴ shoulder,^{5,6} and elbow.⁷ The supposed advantages were preserved periosteal blood supply,⁸ better bone healing,⁹ reduced infection rate, easier fracture

reduction by ligamentotaxis,^{10,11} and better cosmetic in response to growing patient expectancies.¹

Concerning wrist surgery, minimally invasive plate osteosynthesis (MIPO) technique has been used without being named since the 2000s,¹¹ and many articles have

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been published since 2013 on this subject.^{12–23} MIPO technique theoretically allows for faster bone healing¹⁵ compared with a conventional Henry's approach^{24,25} by preserving pronator quadratus, the periosteum around the fracture, and the blood supply. Cosmetic advantage is obvious.¹³ A locking volar plate is mostly required in all MIPO technique in wrist surgery.²⁶

Some authors have extended MIPO technique to metadiaphyseal fractures of the distal radius using long volar plate,^{22,23,27} but no study comparing one or two longitudinal incisions to conventional approach has yet been published.

The purpose of this study was to compare clinical and radiologic outcomes of MIPO versus conventional approach for metadiaphyseal fractures of the distal radius using a long volar plate.

Materials and Methods

All patients' files of metaphyseal fracture of distal radius treated with a long volar plate between January 2008 and January 2016 in our department were reviewed. Inclusion criterion of the study was metadiaphyseal fractures of distal radius requiring a long volar plate with at least eight holes in its proximal part. Patients younger than 18 years and shorter follow-up of less than 2 months were excluded from the study. Thirty-nine fractures in 38 patients were selected, and among them, 7 patients were excluded: 1 death, 3 lost to follow-up, 3 incomplete files. The cohort consisted of 32 fractures in 31 patients (16 males and 15 females) with a mean age 63.9 years old (range: 23–87) (► **Tables 1, 2**).

All surgeries were performed under regional axillary block, 20 as day case, and 11 were in conventional hospitalization due to associated lesions or comorbidities (► **Tables 1, 2**). Fifteen patients underwent MIPO technique (group 1) and 16 patients (17 fractures) underwent a conventional approach longer than 60 mm of the skin incision (group 2).

MIPO technique consisted of a first 15- to 30-mm distal incision, along classic Henry's approach, 15 mm proximally to the apex of radial styloid.¹⁷ A long volar plate was then inserted under pronator quadratus. Epiphyseal screws were placed under fluoroscopic control. A second 15- to 30-mm proximal incision, along Henry's approach, was then made after fluoroscopic guidance at the level of the proximal part of the plate. Proximal screws were fixed to reduce the fragment(s). Both incisions were closed by 4/0 Monocryl (Ethicon, Somerville, NJ) (► **Fig. 1**) running stitch. In 26 cases, early postoperative mobilization was allowed.

Perioperative evaluations were length of the skin incisions in mm and tourniquet time in minutes.

At latest follow-up, subjective and objective evaluations measuring six clinical variables, three radiologic one, and identifying complications. In subjective measurement, pain was evaluated on a numerical scale from 0 (no pain) to 10 (maximum pain) (visual analogue scale [VAS]). Functional outcome was also assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, grading from 0 (perfectly functional upper extremity) to 100 (com-

plete impairment). In objective evaluations, grip strength (kilograms) was measured using a Jamar hydraulic hand dynamometer in position 2 (Baseline Hydraulic Hand Dynamometer, Fabrication Enterprises Incorporated, Elmsford, NY) and expressed in percentage of contralateral grip. Range of motion (ROM) in flexion-extension, radial and ulnar deviation, and pronation-supination were analyzed in percentage of contralateral side. Radiologically, volar and radial tilts in degrees and ulnar variance in millimeter were assessed. Postoperative complications (infection, secondary displacement, complex regional pain syndrome [CRPS], tendon rupture) were also examined.

Statistical analysis consisted of comparing the means of 11 nonpaired quantitative data (skin incision size, tourniquet time, pain, quick DASH score, grip strength, ROM in flexion, extension, radial and ulnar deviation, pronation and supination, three radiologic data).

Considering the small size of our sample, older measurements of *p* values were not reliable. We thus turned to newer methods of bayesian analysis. These measure the distribution of the T coefficient and then calculate the probability of observing a difference or not. This method defines a probability with greater power between 0 and 1, more precise than a binary response with a *p* value larger or smaller than 0.05. If the interval of the T coefficient did not contain 0 and the probability was superior to 97.5%, the difference was considered significant.

Results

Perioperative results are presented in ► **Tables 1 and 2**.

Mean distal incision size was 23.5 mm and proximal one 16.9 mm. Mean global size (sum of both incisions) was 42.9 mm in group 1 and 83.8 mm in group 2. T coefficient of 40.9 (30.57–50.98) did not include 0 and corresponded to a *p* = 99.9% that T will be positive. The difference was statistically significant.

Mean tourniquet time was 58.4 minutes in group 1 and 68.4 minutes in group 2. T coefficient of 9.97 (–7.47 to 27.06) included 0 and corresponded to a *p* = 88% probability that T will be positive. The difference was not statistically significant.

Results at latest follow-up are presented in ► **Tables 3 and 4**.

In the subjective analysis, mean pain was 1.5/10 in group 1 and 2.6/10 in group 2. T coefficient of 1.116 (–0.3 to 2.52) included 0 and corresponded to a *p* = 94% probability that T will be positive. The difference was not statistically significant. Mean quick DASH score was 22.88/100 in group 1 and 28.98/100 in group 2. T coefficient of 5.892 (–8.72 to 20.3) included 0 and corresponded to a *p* = 79% probability that T will be positive. The difference was not statistically significant.

Objectively, mean grip strength was 65.4% in group 1 and 69.4% in group 2. T coefficient of 3.962 (–10.28 to 18.44) included 0 and corresponded to a *p* = 70% probability that T will be positive. The difference was not statistically significant. Mean flexion was 82.87% in group 1 and 82.94% in group 2. T coefficient of 0.031 (–11.04 to 11.22) included 0

Table 1 Clinical data of 15 metadiaphyseal fractures of distal radius fixed by long volar plate using MIPO technique

Patient		Fracture		Treatment							Associated lesions	Comorbidities
Patient (n)	Age (an)	Sex (M/F)	Classification (AO)	Skin (I/S/O)	Plate (N/A)	Skin incision		Tourniquet (min)	Immobilization (Y/N)	Associated interventions		
1	74	M	23 A 2.2	O	S	18	18	120	N	Temporary pinning		Malunion, diabetes
2	56	F	23 A 3.3	I	A	20	20	66	N			
3	62	M	23 A 3.3	I	A	20	20	58	N			Chronic pancreatitis
4	76	F	23 A 3.3	I	N	15	15	30	N		# humeral neck	
5	63	M	23 A 3.3	I	N	20	20	59	N			
6	57	M	23 A 3.3	I	N	40	20	47	N			RA, CTH
7	83	F	23 A 3.3	O	N	15	15	45	N			Alzheimer
8	57	F	23 A 3.3	I	N	15	15	50	N			RA, diabetes
9	40	M	23 C 2.3	I	N	15	15	62	N	Arthroscopy	# femoral neck	
10	52	M	23 C 3.2	I	N	30	15	62	N			
11	42	M	23 A 2.3	I	N	35	35	50	N			MS
12	23	F	23 C 3.3	O	N	40	20	60	N			
13	44	M	23 C 1.2	I	N	20	20	39	N			
14	58	F	23 A 3.3	I	N	20	20	58	N			Cognitive impairment
15	49	M	22 A 2.3	I	N	30	20	70	Y		# L1	

Abbreviations: #, fracture ; A, Acumed; CTH, chemotherapy; F, female; I, intact; M, male; MIPO, minimally invasive plate osteosynthesis; MS, multiple sclerosis; N, Newclip Technics; O, open; RA, rheumatoid arthritis; S, scratches; S, Synthes.

Table 2 Clinical data of 17 metadiaphyseal fractures of distal radius treated by long volar plate using a conventional approach

Patient (n)	Fracture		Treatment		Tourniquet (min)	Immobilization (Y/N)	Associated intervention	Associated lesions	Comorbidities
	Age (an)	Gender (M/F)	Classification (AO)	Skin (I/S/O)	Plate (N/A/M/S)				
1	24	M	22 A.3.3	O	N		Ulna ORIF, fasciotomy	Contralateral wrist #	
2	24	M	23 A.3.3	O	A		ulna + M2 ORIF, fasciotomy	Contralateral wrist #, M2#	
2'	61	F	23 C.2.3	I	S				
3	43	M	23 A.3.3	I	N				
4	72	F	23 A.3.3	I	M				
5	70	M	23 A.3.3	I	N		Hardware removal (SD)	Contralateral wrist #	
6	81	F	23 A.3.3	O	N	Y	Cimentoplastie		
7	82	F	23 C.2.3	I	N	N			Epilepsy
8	87	F	23 A.3.3	S	N	N			
9	73	F	23 C.3.3	O	N	Y	PP L5 ORIF	PP L5 #	Hémiplégie
10	62	F	23 C.3.3	I	N	N	Hardware removal (SD)		L hémiplégie
11	64	F	23 A.3.3	I	N	Y			Radius malunion
12	76	F	23 C.2.3	S	M	Y			
13	70	M	23 A.3.3	I	N	N			
14	52	M	23 C.2.2	I	N	N			
15	79	M	23 C.3.3	O	N	Y			DT II, CKF, CLL
16	85	F	22 A.2.2	I	N	N	Hardware removal		Cognitive impairment

Abbreviations: A, Acumed ; CKF, chronic kidney failure ; CLL, chronic lymphoid leucemia ; DTII, type 2 diabetes ; F, female ; I, intact ; L5, 5th left finger ; M, male ; M, Médart ; M2, 2nd metacarpal ; N, Newclip Techniques ; O, open ; PP, proximal phalanx ; S, SBI ; S, scratches ; SD, secondary displacement.

Fig. 1 MIPO technique for dorsally displaced distal radius fracture using a long volar plate (A) preoperative anteroposterior X-ray view. Note the proximal diaphyseal extension, (B) preoperative lateral X-ray view. Note the dorsal displacement and dorsal comminution, (C) perioperative view. After plate introduction under PQ, K-wires are inserted through the drill guides fixed to the distal holes of the plate. A temporary K-wire has been used to reduce the fracture, (D) perioperative view. A drill guide is fixed to a proximal hole of the plate, (E) perioperative view. After skin closure of both incisions, (F) postoperative anteroposterior X-ray view, (G) postoperative lateral X-ray view.

Table 3 Clinical and radiologic outcomes of 15 metadiaphyseal fractures of distal radius treated by long volar plating using MIPO technique

Patient (n)	Follow-up (mo)	Pain (0–10)	Q DASH (0–100)	Grip strength (%)	ROM			X-Ray		
					F/E (%)	UD/RD (%)	P/S (%)	RT (°)	VT (°)	UV (mm)
1	2	1	45.45	56	50/60	40/50	66/25	5	–8	+7
2	6	3	25	71	80/92	87/75	93/100	28	0	–4
3	8	1	20.45	66	64/100	71/15	100/80	18	10	+4
4	3	0	13.64	55	87/92	100/100	100/80	23	21	–2
5	6	1	4.55	100	100/100	100/92	100/75	28	7	–2
6	4	3	38.64	70	86/50	66/50	100/62	25	0	–5
7	6	0	0	45	100/100	100/100	100/100	14	10	–2
8	2	3	36.36	40	75/87	100/100	100/75	20	5	–3
9	3	0	2.273	96	75/71	71/100	94/94	24	6	–1
10	3	3	65.91	71	81/73	66/100	100/100	22	15	0
11	2	3	25	52	87/100	100/100	93/100	15	5	–3
12	6	0	9.09	100	100/100	100/100	100/100	26	4	2
13	6	0	0	83	100/100	100/94	100/100	11	4	–1
14	3	2	20.45	25	87/33	50/100	92/25	5	–5	0
15	2	3	36.36	50	71/71	100/100	100/100	22	8	–3

Abbreviations: E, extension; F, flexion; MIPO, minimally invasive plate osteosynthesis; P, pronation; RD, radial deviation; ROM, range of motion; RT, radial tilt; S, supination; UD, ulnar deviation; UV, ulnar variance; VT, volar tilt.

Table 4 Clinical and radiologic outcomes of 17 metadiaphyseal fractures of distal radius treated by long volar plating using a conventional approach

Patient (n)	Follow-up (mo)	Pain (0–10)	Q DASH (0–100)	Grip strength (%)	ROM			X-Ray		
					F/E (%)	UD/RD (%)	P/S (%)	RT (°)	VT (°)	UV (mm)
1	5	5	52.27	100	100/100	100/100	100/100	24	10	–2
2	5	5	52.27	55	94/100	87/50	100/86	24	11	–1
2'	14	5	34.09	86	94/92	100/100	94/100	18	13	–1
3	3	3	56.82	55	50/50	85/80	50/50	20	0	–3
4	6	8	61.36	60	86/57	100/100	100/100	15	7	0
5	3	1	22.73	80	71/62	100/100	77/92	22	8	+1
6	4	0	4.55	55	73/87	100/100	100/94	33	20	–4
7	3	2	0	50	100/100	88/100	86/93	28	7	–2
8	5	0	25	78	88/100	67/100	100/88	19	–14	+3
9	13	6	29.55	62	87/93	100/100	80/82	25	–11	–1
10	6	2	20.45	67	87/100	37/100	94/100	20	11	+2
11	8	2	NA	55	89/94	75/100	94/87	13	8	–2
12	2	2	40.90	67	45/45	100/100	100/70	18	–2	–2
13	5	0	4.55	60	71/71	92/92	100/100	25	3	0
14	5	1	11.36	100	100/75	83/75	94/100	24	8	–3
15	6	3	47.73	50	75/100	100/100	71/100	26	2	–2
16	4	0	0	100	100/66	100/100	100/87	16	8	–1

Abbreviations: E, extension; F, flexion; NA, nonapplicable; P, pronation; RD, radial deviation; RT, radial tilt; S, supination; UD, ulnar deviation; UV, ulnar variance; VT, volar tilt.

and corresponded to a $p = 50\%$ probability that T will be positive. The difference was not statistically significant. Mean extension was 81.93% in group 1 and 81.95% in group 2. T coefficient of -0.067 (-14.77 to 14.83) included 0 and corresponded to a $p = 94\%$ probability that T will be positive. The difference was not statistically significant. Mean ulnar deviation was 83.4% in group 1 and 89.06% in group 2. T coefficient of 5.514 (-8.17 to 19.18) included 0 and corresponded to a $p = 88\%$ probability that T will be positive. The difference was not statistically significant. Mean radial deviation was 85.07% in group 1 and 93.94% in group 2. T coefficient of 8.635 (-6.07 to 23.61) included 0 and corresponded to a $p = 88\%$ probability that T will be positive. The difference was not statistically significant. Mean pronation was 95.87% in group 1 and 90.59% in group 2. T coefficient of -5.299 (-13.48 to 3.08) included 0 and corresponded to a $p = 10\%$ probability that T will be positive. The difference was not statistically significant. Mean supination was 81.2% in group 1 and 89.84% in group 2. T coefficient of 8.644 (-5.91 to 23.11) included 0 and corresponded to a $p = 87\%$ probability that T will be positive. The difference was not statistically significant.

Radiologic analysis indicated that mean radial tilt was 19 degrees in group 1 and 21.77 degrees in group 2. T coefficient of 2.691 (-1.95 to 7.35) included 0 and corresponded to a $p = 87\%$ probability that T will be positive. The difference was not significant. Mean volar tilt was of 5.47 degrees in

group 1 and 5.25 degrees in group 2. T coefficient of -0.22 (-5.91 to 5.36) included 0 and corresponded to a $p = 47\%$ that T will be positive. The difference was not significant. Mean ulnar variance was -0.873 mm in group 1 and -1.1063 mm in group 2. T coefficient of -0.19 (-2.08 to 1.75) included 0 and corresponded to a $p = 41\%$ probability that T will be positive. The difference was not significant.

One complication was noted in group 1 and none in group 2. It was an extensor pollicis longus rupture requiring hardware removal and tendon transfer 6 months after the initial plate fixation.

Discussion

Popularity of MIPO techniques for the distal radius increases both in the extra-articular distal radius fractures¹² and in the articular¹⁵ or metadiaphyseal fractures of the distal radius.²² Arthroscopy is generally indicated when anatomical reduction cannot be achieved after plate fixation in the articular distal radius fractures.^{16,28} Two incisions, proximal and distal, are recommended in case of metadiaphyseal fracture.²⁰ Conversion to a conventional approach is always feasible in case of difficulties.

Approaches for metaphyseal fracture osteosynthesis of distal radius are differentiated according to size and orientation. Skin incisions vary from 30 to 50 mm^{14,21} as the result of the sum of both incisions. It seems logical to define the

MIPO technique for the distal radius by a global skin incision equal or lower than 60 mm. The proximal skin incision, through which are fixed diaphyseal screws, is always longitudinal and often shorter. The distal one is either longitudinal,^{12,14} transverse,^{13,15,20–23} oblique,²⁷ or crescent-shape.²³ Some authors found that the transverse skin incision might bother some patients by being misinterpreted as a phlebotomy scar,¹⁵ but they also claimed that it could be invisible if realized in a wrist crease. Oblique and transverse incisions limit the access to radial epiphysis, and crescent-shape incisions give inferior cosmetic results. Our results demonstrate that two longitudinal incisions along classic Henry's approach allow sufficient access to radial epiphysis, with good cosmetic results and easy conversion to a conventional approach is possible at any time.

Our results demonstrate that MIPO technique has several advantages compared with conventional approach. Cosmetic results are superior, size of skin incision being twice shorter. Knowing that every minute in the OR costs €10,³¹ the cost of the procedure might be reduced by €100 per patient, operating time being expected to be 10 minutes shorter. Clinical and radiologic outcomes were not better or poorer.

This study has several limitations. First, this is a retrospective study, implying that the patients could not be randomly assigned. Second, this is a small sample due to the occurrence of those fractures. Relatively shorter follow-up was noted.

In conclusion, MIPO technique for long volar plating of metaphyseal fractures of distal radius has cosmetic and economic advantages compared with the conventional approach. Conversion to a conventional approach is always allowed in case of technical difficulties.

Note

This work was performed at the Department of Hand Surgery, Strasbourg University Hospitals, FMTS, Strasbourg University, Illkirch, France.

Author Contributions

Emilie Pire: collected data, wrote manuscript; Juan José Hidalgo Díaz: translation from French to English; Santiago Salazar Botero: collected data; Sybille Facca: operated some cases; Philippe Liverneaux: operated most cases, wrote manuscript.

Conflict of Interest

Philippe Liverneaux has conflict of interest with Newclip Technics, France, Argo Medical, Switzerland, and Biomodex, France. None of the other authors have conflict of interest.

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