Minimally Invasive Plate Osteosynthesis for Extra-articular Distal Radius Fracture in Postmenopausal Women: Longitudinal versus Transverse Incision

Chloé Galmiche, MD¹ Gustavo Gómez Rodríguez, MD² Fred Xavier, MD³ Yuka Igeta, MD⁴
Juan José Hidalgo Díaz, MD¹ Philippe Liverneaux, MD, PhD¹

¹Department of Hand Surgery, University Hospital of Strasbourg, Fédération de Médecine Translationnelle de Strasbourg, University of Strasbourg, Illkirch, France

²Centro Artro, Clinic of the Hand of Buenos Aires, British Hospital of Buenos Aires, Buenos Aires, Argentina

³Department of Spine Surgery, QEII Health Sciences Centre – Halifax Infirmary, Dalhousie University, Halifax, Nova Scotia, Canada

⁴Department of Orthopedic Surgery, Juntendo University, Tokyo, Japan

Address for correspondence Philippe Liverneaux, MD, PhD, Department of Hand Surgery, Strasbourg University Hospitals, 10 Avenue Baumann, F-67403 Illkirch, France
(e-mail: Philippe.liverneaux@chru-strasbourg.fr).

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Abstract

Background This work aimed to compare two mini-invasive palmar approaches (longitudinal and transverse) to osteosynthesize fractures of the distal radius. The main hypothesis was that the longitudinal technique gave smaller incisions. The secondary hypothesis was that the longitudinal technique would be better for the recovery of pain, functional scores, strength, and mobility.

Materials and Methods The series included 30 extra-articular distal radius fractures in 30 patients (average age: 74 years) fixed with volar locking plate using a mini-invasive technique. Fifteen of these patients had a single longitudinal surgical approach (Group I), and 15 had a transverse approach that was completed with a longitudinal incision for the proximal screws (Group II).

Results The combined average incision size was 14.73 mm in Group I and 19.8 mm in Group II. After 6 months, the pain was on average 1.4/10 (Group I) and 0.46/10 (Group II), the quick Disability of the Arm, Shoulder, and Hand was 13.63/100 (Group I) and 2.8/100 (Group II), Patient-Related Wrist Evaluation was 11.8/100 (Group I) and 5.97/100 (Group II), grip strength was 81.06% (Group I) and 72.13% (Group II), flexion was 88.13% (Group I) and 75% (Group II), extension was 86% (Group I) and 64.6% (Group II), ulnar inclination was 89% (Group I) and 78.67% (Group II), radial inclination was 89.73% (Group I) and 79.93% (Group II), pronation was 96.67% (Group I) and 81.46% (Group II), and supination was 91.93% (Group I) and 79.87% (Group II).

Clinical Relevance The longitudinal technique gave smaller incisions than the transverse technique. Among the secondary hypotheses, all the variables were better with the longitudinal technique, except the pain, although without any significant difference.

Keywords

- ▶ distal radius fracture
- ▶ minimally invasive plate osteosynthesis
- ▶ postmenopausal

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Minimally invasive surgery has progressively established itself in orthopaedic and trauma surgery of the lower limb: percutaneous surgery of the forefoot, knee arthroscopy, knee and hip prostheses, and osteosynthesis of the trochanteric mass.¹ On the wrist, there are three types of semi-invasive approaches for fixation of extra-articular fractures of the distal radius: dorsal^{2,3} or lateral⁴ for the placement of a locked intramedullary nail, and palmar for an volar locking plate.⁵

Concerning the palmar approach, some authors have described a longitudinal route⁶ and others a transversal path.⁷ Both use the same plates for standard techniques. The aim of this work was to compare the aesthetic and functional results of minimally invasive plate osteosynthesis (MIPO) palmar surgery in the treatment of extra-articular distal radius fractures in postmenopausal patients: longitudinal and transverse.

The main hypothesis of this work was that the longitudinal MIPO approach yielded smaller incisions than the transverse MIPO technique. Secondary hypotheses were that the longitudinal MIPO technique gave better results than the transversal MIPO in terms of pain, functional scores, strength, and mobility.

Materials and Methods

The records of all patients managed in two hand surgery centers for a distal radius fracture stabilized by volar locking plate in the past 5 years were studied retrospectively. Patients younger than 50 years, men, polyfractures or polytrauma, comminuted fractures, intra-articular fractures, volarly displaced intra-articular fractures, and open intra-articular fractures were all excluded. Included were isolated closed fractures of the extra-articular distal radius with posterior displacement less than 30 degrees, with a minimum follow-up of 6 months in postmenopausal women older than 50 years. Our series included 30 fractures in 30 patients with an average age of 74 years (range: 66–90).

All fractures were stabilized by an anatomic locking plate on the anterior aspect of the distal radius (Initial R, Newclip Technics, Haute-Goulaine, France) using a minimally invasive technique. The 15 fractures managed in the first center (Group I) were operated by a single longitudinal minimally invasive approach⁸ (►Fig. 1). The fractures managed in the second center (Group II) were operated by a transverse minimally invasive approach to insert the plate and the distal epiphyseal screws. The proximal diaphyseal screws were subsequently placed via an accessory longitudinal approach⁵ (►Fig. 2).

The outcome evaluation method consisted of immediate postoperative measurement of the total incision size in mm, which represents the size of the single longitudinal incision in Group I, and the sum of the transverse and longitudinal incisions in Group II. Six months after the surgery, the pain was measured on a visual analog scale from 0 (no pain) to 10 (maximum pain imaginable), the overall function of the hand by the quick Disability of the Arm, Shoulder, and Hand (DASH) from 0 (normal function) to 100 (unusable upper limb),⁹ Patient-Related Wrist Evaluation (PRWE) from 0 (normal function) to 100 (upper limb unusable),¹⁰ the force of the grip using the Jamar dynamometer placed in position 2 (Sammsons Preston Ryolan™, Bolingbrook, IL), expressed as a percentage of contralateral side, wrist mobility (flexion, extension, ulnar inclination, radial inclination, pronation, and supination) expressed as a percentage of the contralateral side. Peri- and postoperative complications were noted.

Statistical analysis was performed to compare the 11 quantitative variables (pain, quick DASH, PRWE, grip strength, flexion, extension, ulnar inclination, radial inclination, pronation, supination, and incision's length). Given the small numbers in our sample, the old so-called frequentist methods, expressed as *p*-values, have only a weak power. In this work, we used Bayesian analysis methods, which consist in calculating the probability of observing a difference or not, which have a greater power. A probability of a difference in credibility intervals

Fig. 1 Longitudinal minimally invasive plate osteosynthesis technique for extra-articular distal radius fractures. (A) The deep surface of the pronator quadratus muscle is released using a rongeur. (B) The plate is positioned under the pronator quadratus muscle. Note the two drilling guides for the epiphyseal screws. (C) Final incision.

Fig. 2 Transverse minimally invasive plate osteosynthesis technique for extra-articular distal radius fracture. (A) The deep surface of the pronator quadratus muscle is released using a rongeur. (B) The plate is positioned under the pronator quadratus muscle. (C) Additional proximal longitudinal incision to insert the proximal screws. (D) Final incisions.

between the two groups of more than 90% corresponded to a large difference, of more than 95% to a very large difference, and of more than 97.5% to the equivalent of one significant difference. All the analysis was performed using software R in version 3.2.2 (<https://www.r-project.org/>).

Results

The analytical results are presented in ►Tables 1 and 2. The total size of the incision was on an average 14.73 mm in Group I and 19.8 mm in Group II, with an estimated significant difference of -5.325 .

At more than 6 months, the average pain was 1.4/10 in Group I and 0.46/10 in Group II, with an estimated very large difference of 0.439. The quick DASH averaged 13.63/100 in

Group I and 2.8/100 in Group II, with an estimated significant difference of 5.566. The PRWE averaged 11.8/100 in Group I and 5.97/100 in Group II, with an estimated not significant difference of 2.844. The average grip strength was 81.06% in Group I and 72.13% in Group II, with an estimated very large difference of 9.238. The average wrist flexion was 88.13% in Group I and 75% in Group II, with an estimated not significant difference of 2.999. The wrist extension averaged 86% in Group I and 64.6% in Group II, with an estimated significant difference of 9.255. Ulnar inclination averaged 89% in Group I and 78.67% in Group II, with an estimated not significant difference of -0.421 . Radial inclination averaged 89.73% in Group I and 79.93% in Group II, with an estimated not significant difference of -0.812 . Pronation averaged 96.67% in Group I and 81.46% in Group II, with an estimated large

Table 1 Results of a series of 15 patients older than 50 years treated by ORIF for an extra-articular fracture of the distal radius by anterior locking plate with a minimally invasive longitudinal approach

Patient (n)	Follow-up (mo)	Incision size (mm)			Pain (0–10)	Quick DASH (0–100)	PRWE (0–100)	Force (%)	Motion (%)					
		Main	Extra	Total				Position 2	F	E	UI	RI	P	S
1	17	12	0	12	0	0	1	100	87	100	100	100	100	100
2	11	16	0	16	0	0	0	63	92	92	57	75	104	66
3	10	15	0	15	0	6.82	1	66	71	71	50	100	83	71
4	7	18	0	18	1	27.27	15	88	92	80	75	100	86	100
5	7	13	0	13	2	13.64	13	85	100	100	100	100	100	100
6	7	12	0	12	0	2.27	5	100	88	92	100	66	116	100
7	6	14	0	14	0	0	0	40	82	75	85	75	94	75
8	6	15	0	15	0	0	5	83	77	100	100	100	100	100
9	6	18	0	18	2	20.45	20	66	86	93	100	100	100	93
10	12	14	0	14	4	36.36	32	105	82	85	83	80	81	100
11	6	15	0	15	1	6.82	2	125	93	76	100	100	93	94
12	7	10	0	10	0	0	0	81	100	114	100	100	100	100
13	6	20	5	25	3	11.36	13	68	93	80	114	50	93	80
14	6	10	0	10	2	20.45	11	71	87	60	100	100	100	100
15	6	14	0	14	6	59.09	59	75	92	72	71	100	100	100

Abbreviations: DASH, Disability of the Arm, Shoulder, and Hand; E, extension; F, flexion; ORIF, open reduction and internal fixation; P, pronation; PRWE, Patient-Related Wrist Evaluation; RI, radial inclination; S, supination; UI, ulnar inclination.

Note: Extra: incision size in case of need of an extra incision for proximal screw insertion; Force (%): percentage of force compared with contralateral healthy side; and total incision size: main incision size + extra incision size.

Table 2 Results of a series of 15 patients older than 50 years treated by ORIF for an extra-articular fracture of the distal radius by anterior locking plate with a minimally invasive transverse approach

Patient (n)	Follow-up (mo)	Incision size (mm)			Pain (0–10)	Quick DASH (0–100)	PRWE (0–100)	Force (%)	Motion (%)					
		Main	Extra	Total				Position 2	F	E	UI	RI	P	S
1	12	21	5	26	0	2.3	11.5	72	73	74	88	75	83	84
2	11	17	5	22	0	0	3	84	91	76	100	100	92	93
3	10	18	4	22	0	4.5	11	73	68	65	72	75	77	74
4	10	16	3	19	1	6.8	15	63	83	54	75	77	73	69
5	9	17	4	21	0	0	2	84	82	63	69	68	83	78
6	9	15	3	18	1	6.8	13	67	76	71	88	100	82	76
7	9	15	5	20	0	0	1	83	84	73	72	74	92	86
8	8	18	3	21	3	13.6	17	43	46	42	59	62	53	67
9	8	15	3	18	1	4.5	6	60	72	56	64	69	76	74
10	8	13	4	17	0	0	2	81	68	62	69	74	83	81
11	7	17	3	20	0	0	0	92	83	69	93	100	91	87
12	7	15	3	18	0	0	0	80	85	73	100	100	89	86
13	7	16	3	19	0	0	1	67	60	49	55	56	79	81
14	6	15	3	18	0	0	0	71	81	78	100	91	83	79
15	6	15	3	18	1	4.5	7	62	73	64	76	78	86	83

Abbreviations: DASH, Disability of the Arm, Shoulder, and Hand; E, extension; F, flexion; ORIF, open reduction and internal fixation; P, pronation; PRWE, Patient-Related Wrist Evaluation; RI, radial inclination; S, supination; UI, ulnar inclination.

Note: Extra: incision size in case of need of an extra incision for proximal screw insertion; Force (%): percentage of force compared with contralateral healthy side; Total incision size: main incision size + extra incision size.

difference of 5.140. Supination averaged 91.93% in Group I and 79.87% in Group II, with an estimated not significant difference of 1.857.

Discussion

Among minimally invasive techniques developed for the osteosynthesis of extra-articular fractures of the distal radius, the use of intramedullary nails remains controversial,¹¹ probably due to complications such as injury to the extensor apparatus by dorsally inserted nails¹² and to the radial nerve branches by laterally inserted nails.¹³ With the development of volar locking plates, Henry's extended distal anterior approach or trans-flexor carpi radialis (FCR) approach tends to become the gold standard.¹⁴ It has been used to early mobilize the wrist and limit the number of complications, particularly unwanted calluses and type I complex regional pain syndromes.¹⁵ It has some disadvantages, including the nonaesthetic scarring and the loss of ligamentotaxis linked to the disinsertion of articular bone fragments from their capsular, ligament, and muscle attachments. This is why some authors have developed a minimally invasive technique using a longitudinal or a transverse way with conservation of the pronator quadratus muscle.^{16,17} Some authors have shown that it is better to respect the pronator quadratus than to incise it with or without repair.¹⁸ Others suggest that the pronator quadratus participates in the vascularization of the distal radius,¹⁹ stabilizes the distal radioulnar joint,²⁰ participates in 21% of the forearm pronation force,²¹ and promotes bone healing, which speeds up the return to daily activities.¹⁷

The minimally invasive transverse pathway has several disadvantages. On the aesthetic level, not only the localization in a transverse wrist fold can be interpreted as a suicide attempt scar by phlebotomy⁵ but also the need for a second incision to have the proximal screws does not respect the principle of a single incision.⁷ Neurologically, lesions of the palmar cutaneous branch of the median nerve have been described.²² Finally, no author has reported the use of the transverse approach for joint fractures or proximal fractures. The minimally invasive longitudinal path on the radial side of the FCR does not have these disadvantages. It cannot be confused with a suicide attempt scar, does not require an additional incision to have the proximal screws, and avoids the palmar cutaneous branch of the median nerve. Moreover, the longitudinal incision can be extended proximally and/or distally in case of complex fractures.²³

As a weakness of our series, the patients were operated in two different centers. As strength of our series, the fractures were similar in both groups. The difference between both groups cannot be explained by the fracture but by the length and direction of the incision. The results of our series confirmed the superiority of the longitudinal approach, all indicators of which were better than those of the transverse, except pain, although not significant.

The primary hypothesis of this work was confirmed, and the longitudinal MIPO approach gave significantly smaller incisions than the transverse MIPO technique. Among

the secondary hypotheses verified, all the variables were better with the longitudinal MIPO technique, two with a significant difference (quick DASH, wrist extension) and seven with a nonsignificant difference (PRWE, force, flexion of the wrist, ulnar and radial inclinations, pronation, and supination).

In conclusion, in the course of anterior locking plate osteosynthesis for isolated extra-articular distal radius fractures with posterior displacement, the longitudinal MIPO technique gives better functional and esthetic results than the transverse MIPO approach, and allows to extend the incision easily, if necessary.

Conflict of Interest

Philippe Liverneaux has conflict of interest with Newclip Technics, Argomedical, Zimmer Biomet, Biomodex. None of the other authors has any conflict of interest.

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