Orthopaedics & Traumatology: Surgery & Research 105 (2019) 409–415

Contents lists available at ScienceDirect

Orthopaedics & Traumatology: Surgery & Research

journal homepage: www.elsevier.com

Original article

Minimally invasive internal fixation for extra-articular distal radius fracture: Comparison between volar plate and intramedullary nail

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ARTICLE INFO

Article history:
Received 26 May 2018
Accepted 22 October 2018

Keywords:
Volar plate
Distal radius fracture
MIPO
Minimally invasive
Nailing

ABSTRACT

Introduction: There are numerous internal fixation techniques for distal radius fracture, using pins, plates or nails. Some authors have developed minimally invasive procedures. The aim of the present study was to compare two minimally invasive internal fixation techniques for unstable extra-articular distal radius fracture in women over 50 years of age: volar plate (minimally invasive plate osteosynthesis: MIPO), and intramedullary nail.
Hypotheses: The main study hypothesis was that the incision scar left by minimally invasive internal fixation is smaller using MIPO than an intramedullary nail. The secondary hypotheses were that the two techniques do not differ in terms of pain, functional score, strength, range of motion and radiologic indices.
Material and method: The series comprised nineteen A2.2 and one A2.1 fractures in 20 female patients with a mean age of 72 years. The first 10 (group 1) received minimally invasive internal fixation of the distal radius by MIPO, and the other 10 (group 2) by intramedullary nail locked onto the distal radius epiphysis and diaphysis.
Results: The main study hypothesis was confirmed: the incision scar left by minimally invasive internal fixation was smaller using MIPO than an intramedullary nail (mean, 14.3 mm vs. 32.8 mm). Some of the secondary hypotheses were also confirmed: there were no differences between the two techniques in terms of pain at 6 months, QuickDASH, PRWE (Patient-Reported Wrist Evaluation), range of motion or ulnar variance; two were not confirmed: pain at 6 weeks was less with intramedullary nails, and palmar slope was better with MIPO.
Discussion and conclusion: The main study hypothesis was confirmed: the incision scar left by minimally invasive internal fixation was smaller using MIPO than an intramedullary nail. In conclusion, the present findings showed that internal fixation of unstable extra-articular fracture in over 50-year-olds gave better clinical results at 6 weeks using an intramedullary nail, while MIPO required smaller incision.
Level of evidence: III, retrospective study.

1. Introduction

Volar locking plates have become the gold standard for internal fixation of unstable distal radius fracture in perimenopausal women [1]. The technique was described using an extensive approach requiring considerable soft-tissue dissection [2]. Some authors developed a minimally invasive technique using a volar plate (minimally invasive plate osteosynthesis: MIPO) [3] or intramedullary nail [4], to reduce incision size. The aim of the present study was to compare two minimally invasive internal fixation techniques for unstable extra-articular distal radius fracture in women over 50 years of age: MIPO, and intramedullary nail.

The main study hypothesis was that the incision scar left by minimally invasive internal fixation is smaller using MIPO than an intramedullary nail. The secondary hypotheses were that the two techniques do not differ in terms of pain, functional score, strength, range of motion and radiologic indices.

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https://doi.org/10.1016/j.otsr.2018.10.013
1877-0568/

Table 1
Case data in 10 extra-articular distal radius fractures treated by Initial R® plate.

Patient (*n*)	Age (yrs)	Handedness	Affected side	AO classification (A2.1/A2.2/A2.3)	Tourniquet time (min)
1	82	R	R	A2.2	44
2	86	L	L	A2.2	33
3	71	R	L	A2.2	24
4	79	L	L	A2.2	39
5	70	R	L	A2.2	57
6	68	R	L	A2.2	40
7	85	R	L	A2.2	84
8	78	R	L	A2.2	30
9	52	R	R	A2.2	51
10	61	R	R	A2.2	31

R: right; L: left.

Table 2
Case data in 10 extra-articular distal radius fractures managed by Nail-o-Flex®.

Patient (*n*)	Age (yrs)	Handedness	Affected side	AO classification (A2.1/A2.2/A2.3)	Tourniquet time (min)
11	76	R	R	A2.2	47
12	59	R	L	A2.2	65
13	84	R	L	A2.1	60
14	69	R	R	A2.2	44
15	69	R	R	A2.2	70
16	60	R	L	A2.2	58
17	66	R	L	A2.2	30
18	53	R	L	A2.2	65
19	71	R	R	A2.2	50
20	93	R	R	A2.2	59

R: right; L: left.

2. Material and methods

The local review board approved this retrospective study. Files of all female patients managed in our department for closed extra-articular distal radius fracture with posterior displacement between December 2016 and January 2017 were analyzed retrospectively. Patients under 50 years of age or with multiple fractures or multiple trauma, joint fracture, anterior displacement or open fracture were excluded. The series comprised nineteen A2.2 and 1 A2.1 fractures on the AO classification [5], in 20 patients with a mean age of 72 years (range, 52–93 years) (Tables 1 and 2).

All procedures were performed as day surgery under locoregional anesthesia with pneumatic tourniquet.

The first 10 fractures (group 1) were managed by anatomic plate locked onto the anterior side of the distal radius (Initial R®, Newclip Technics™, Haute-Goulaine, France) via a minimally invasive approach (MIPPO) [3] (Fig. 1).

The other 10 (group 2) were managed by intramedullary nail locked onto the epiphysis and diaphysis of the distal radius (Nail-o-Flex®, Evolutis™, Briennon, France) via a minimally invasive approach. After a 1 cm incision proximal to the radial styloid to allow a hole to be drilled in the tip of the radial styloid using

Fig. 1. AO2.2 distal radius fracture fixation by volar locking plate (Initial R®, Newclip Technics™, Haute-Goulaine, France) (patient no. 7): a: preoperative X-ray; b: postoperative X-ray; c: incision at last follow-up: 14 mm.

Fig. 2. AO2.2 distal radius fracture fixation by intramedullary locking nail (Nail-o-Flex®, Evolutis™, Briennon, France) (patient no. 12): a: preoperative X-ray; b: postoperative X-ray; c: incision at last follow-up: 30 mm with skin retraction.

a 2.5-mm bit, the nail, mounted on its guide, was introduced halfway; after fracture reduction by external maneuver, the nail was pivoted through 180°, inserted down to the head and locked by 3 or 4 transverse screws introduced percutaneously (Fig. 2).

No postoperative immobilization was prescribed in either group and patients were encouraged to mobilize the limb immediately.

Tourniquet time was measured in minutes.

Total scar length or lengths was measured in millimeters; there was only 1 scar in group 1 but several in group 2: 1 for positioning the nail, and others for positioning the locking screws.

Assessment consisted in measurement, at initial consultation, short term (6 weeks) and medium term (6 months), of: pain on a numeric scale from 0 (no pain) to 10 (maximum imaginable pain); global hand function on QuickDASH, from 0 (normal function) to 100 (upper limb unusable) [6]; Patient-Reported Wrist Evaluation (PRWE), from 0 (normal function) to 100 (upper limb unusable) [7]; the mean result of 3 wrist strength tests on a Jamar dynamometer in position 2 (Sammons Preston Ryolan®, Bolingbrook, IL, USA), expressed as percentage of contralateral values; wrist passive range of motion on a goniometer (flexion, extension, ulnar inclination, radial inclination, pronation, supination), expressed as percentage of contralateral values; palmar slope, in degrees; and distal ulnar variance, in mm. Intra- and postoperative complications were recorded.

Statistical analysis first checked that the 2 groups were comparable for handedness, age, side and AO grade. Median values were compared for 16 non-matched quantitative variables: tourniquet time, pain QuickDASH, PRWE, wrist strength, wrist passive range of motion, total scar length, palmar slope and distal ulnar variance. Given the small sample sizes, classical "frequentist" methods using *p*-values would have lacked power, and much more powerful Bayesian analysis was used, calculating the probability of observing a difference or not. This gives a probability between 0 and 1, which is more precise than the binary outcome $p > 0.05$. A probability of

Table 3
Short-term results in 10 extra-articular distal radius fractures managed by Initial R® plate.

Patient (*n*)	Follow-up (months)	Pain (0–10)	QuickDASH (0–100)	PRWE (0–100)	Wrist strength, %	Passive range of motion, %						Incision length (mm)	Palmar slope (°)	Ulnar variance (mm)	Complications
						F	E	UI	RI	P	S				
1	1.5	4	59.09	54	50	75	57	71	67	100	100	15	13	0	0
2	1.5	3	22.73	29	82	100	100	87	100	100	100	12	3	−3,5	0
3	1.5	7	77.27	54	25	70	56	86	50	70	47	14	13	0	0
4	1.5	7	59.09	95	27	71	93	100	100	100	100	15	2	0	0
5	1.5	2	31.82	39	85	62	70	100	100	94	94	16	8	−1	FPL adherence
6	1.5	2	52.27	30	57	94	75	100	100	100	100	10	10	−2.5	0
7	1.5	1	13.64	11	36	75	75	75	80	94	71	14	3	0	0
8	1.5	3	15.91	27	47	41	63	57	100	100	35	14	10	0	0
9	1.5	6	45.45	17	55	75	100	75	200	100	75	17	12	+2	0
10	1.5	3	61.36	85	36	78	85	75	75	100	100	12	14	−2	0

%: % of contralateral value; F: flexion; E: extension; UI: ulnar inclination; RI: radial inclination; P: pronation; S: supination; FPL: flexor pollicis longus.

Table 4
Short-term results in 10 extra-articular distal radius fractures managed by Nail-o-Flex®.

Patient (*n*)	Follow-up (months)	Pain (0–10)	QuickDASH (0–100)	PRWE (0–100)	Wrist strength, %	Passive range of motion, %						Incision length (mm)						Palmar slope (°)	Ulnar variance (mm)	Complications
						F	E	UI	RI	P	S	A	B	C	D	E	Total			
11	2	6	84.09	79	30	64	37	75	75	83	94	15	5	0	0	20	40	+4	0	0
12	1,5	2	50	58	12,5	33	60	50	100	94	61	5	5	0	0	27	37	1	−2.5	0
13	1,5	1	15.91	17	57	54	122	86	50	100	67	4	6	0	0	21	31	−2	+2.5	0
14	1.5	0	13.64	11	100	110	77	100	50	160	77	3	3	0	0	25	31	+7	+1	0
15	1.5	1	15.91	17	50	89	77	100	100	87	83	10	16	5	5	5	41	+10	+2.5	0
16	1.5	0	18.18	6	31	90	84	100	100	100	100	8	8	0	0	10	26	+5	0	0
17	1.5	2	40.91	31	13	37	53	57	50	93	61	12	10	0	0	12	32	−10	+2	0
18	1.5	2	40.91	27	50	36	53	50	75	93	75	5	5	20	0	5	35	+4	−1.8	0
19	1.5	2	40.91	31	30	44	19	57	50	100	100	5	10	0	0	10	25	−4	+3	0
20	1.5	2	18.18	11	30	78	82	86	50	100	100	5	5	5	5	10	30	−5	+2	0

%: % of contralateral value; F: flexion; E: extension; UI: ulnar inclination; RI: radial inclination; P: pronation; S: supination.

Table 5
Medium-term results in 10 extra-articular distal radius fractures operated on by Initial R® plate.

Patient (*n*)	Follow-up (months)	Pain (0–10)	QuickDASH (0–100)	PRWE (0–100)	Wrist strength, %	Passive range of motion, %						Incision length (mm)	Palmar slope (°)	Ulnar variance (mm)	Complications
						F	E	UI	RI	P	S				
1	7	1	27.27	15	88	92	80	75	100	87	100	15	13	0	0
2	7	2	16.64	13	85	100	100	100	100	100	100	12	3	−3.5	0
3	6	0	20.45	20	40	82	75	86	75	94	82	14	13	+1	0
4	7	2	20.45	20	67	87	93	100	100	100	100	15	2	0	0
5	6	0	18.18	19	119	93	77	100	100	94	94	16	9	−1	EPL tear
6	6	0	2.27	5	122	100	88	100	100	100	100	10	6	−3	0
7	6	0	0	4	55	88	100	100	100	67	67	14	3	0	0
8	6	0	6.82	5	69	94	100	85	100	100	82	14	10	0	0
9	6	1	20.45	13	55	75	100	75	200	107	88	15	13	+2.5	0
10	6	1	15.91	32	112	100	100	88	100	100	100	12	14	−2	0

%: % compared to contralateral value; F: flexion; E: extension; UI: ulnar inclination; RI: radial inclination; P: pronation; S: supination; EPL: extensor pollicis longus.

inter-group difference in confidence intervals > 90% counted as a strong difference, > 95% as a very strong difference, and > 97.5% as the equivalent of a classical significant difference. Analysis used R, version 3.1.0, and JAGS software.

3. Results

Analytic results are shown in Tables 3–6 and synthetic results in Table 7.

There were no intraoperative complications. Postoperatively, there was 1 extensor pollicis longus tear in group 1, treated by extensor indicis transfer.

Mean tourniquet time was 43.3 min in group 1 and 54.8 min in group 2.

Mean scar length was 14.3 mm in group 1 and 32.8 mm in group 2.

Functional results at 6 weeks/6 months in groups 1 and 2 were respectively: pain (/10) 3.59/0.85 and 1.74/0.76; QuickDASH (/100) 39.05/14.51 and 29.23/14.65; PRWE (/100) 43.14/17.08 and 28.58/14.3; wrist strength (% of contralateral) 52.34/78.54 and 48.22/66.06; flexion (% of contralateral) 77.86/91.86 and 78.09/85.76; extension 81.18/92.73 and 82.78/91.41; ulnar inclination 85.93/92.37 and 87.43/89.72; radial inclination 97.97/106.64 and 90.26/89.73; pronation 99.56/97.31 and 107.28/105.66; and supination 86.46/92.6 and 91.57/93.5.

Table 6
Medium-term results in 10 extra-articular distal radius fractures operated on by Nail-o-Flex®.

Patient (*n*)	Follow-up (months)	Pain (0–10)	QuickDASH (0–100)	PRWE (0–100)	Wrist strength, %	Passive range of motion, %						Incision length (mm)						Palmar slope (°)	Ulnar variance (mm)	Complications
						F	E	UI	RI	P	S	A	B	C	D	E	Total			
11	6	2	50	16	50	92	75	87	50	92	75	15	5	0	0	20	40	+6	+1	0
12	6	1	34.09	33	60	40	73	63	50	95	78	5	5	0	0	27	37	1.5	−2	0
13	6	0	6.82	10	62	72	122	100	50	100	83	4	6	0	0	21	31	0	+2.5	0
14	6	0	0	0	78	100	100	50	100	100	75	3	3	0	0	25	31	+8	+1	0
15	6	0	13.64	25	75	100	67	100	100	106	89	10	16	5	5	5	41	+6	+1.5	0
16	6	0	0	0	67	79	100	100	50	86	100	8	8	0	0	10	26	+3	−1	0
17	6	1	6.82	10	50	52	60	71	75	100	78	12	10	0	0	12	32	−10	+2	0
18	6	1	25	9	90	64	93	60	100	106	78	5	5	20	0	5	35	+8	−2	0
19	6	1	34.09	21	57	83	56	67	60	87	100	5	10	0	0	10	25	+2.5	+2	0
20	6	0	9.09	9	86	82	91	100	100	87	78	5	5	5	5	10	30	−9	2	0

%: % compared to contralateral value; F: flexion; E: extension; UI: ulnar inclination; RI: radial inclination; P: pronation; S: supination.

Radiographic results at 6 weeks/6 months in groups 1 and 2 were respectively: palmar slope (°) 10.55/10.39 and 2.14/2.69; distal ulnar variance (mm) −1.2/−1.1 and 0.2/0.03.

4. Discussion

The aim of the present study was to compare two minimally invasive internal fixation techniques for unstable extra-articular distal radius fracture in over 50-year-old women: MIPO, and intramedullary nail.

Short-term clinical results were better in group 2 (nail), with a significant difference for pain and strong probability for PRWE, whereas palmar slope was significantly better in group 1 (plate). Medium term clinical and radiological results were better in group 1, with a strong probability for wrist strength and radial inclination and a significant difference for palmer slope.

Internal fixation of posterior displacement fracture on a palmar approach was developed in the 2000s, and provides stable fixation without the drawbacks of a dorsal approach [8]. Locking plates were developed to fix extra-articular and simple fractures [9]. An extension of the classical flexor carpi radialis (FCR) approach was described, to improve operative exposure, reduce severe joint displacement and release adherences on the dorsal cortex in radial fracture treated secondarily or in recent malunion [2]. Minimally invasive approaches were developed for the same reasons but seeking to spare soft tissue and reduce scar blemish [10].

Biomechanical studies consistently show superiority for nails over plates, in terms of resistance in both compression and flexion [11,12]. The literature contains clinical studies comparing internal fixation by nail on a minimally invasive approach and by plate on a conventional approach [13,14].

One study reported significantly longer operative time for plate fixation (49 min) than with the Targon® nail (45 min) [13]. The present results with Nail-o-Flex® were the opposite.

Clinically, a meta-analysis of 8 articles found no difference in functional results on the two techniques beyond 3 months [14]. One study reported faster short-term recovery of extension pain relief with the Micronail® system [15]. Recovery of extension is probably faster with nails because reduction of posterior displacement is poorer than with plates. The present clinical results showed no difference between the two in terms of wrist extension.

Radiologically, one study reported no significant difference using the Targon® nail [13], contrary to the present findings with Nail-o-Flex® and another study with Micronail® [16]. This may be due to lack of anteversion with certain nails.

Regarding complications, the number of tendon tears [16] and carpal tunnels was reported to be greater with plates, while radial nerve sensory branch irritation and the number of screws in the radioulnar joint were greater with the Targon® nail [13]. In the present series, there was 1 extensor pollicis longus tear in the MIPO group and no complications with nails.

Regarding indications, intramedullary nails have been used in both intra- and extra-articular fracture [14]. The present study included only extra-articular fracture, as Nail-o-Flex® allows only a single screw in the epiphysis and cannot fix multiple fragments.

Short-term clinical results were better in group 2, with a significant difference for pain and a strong probability for PRWE, although palmar slope was significantly better in group 1, perhaps because soft-tissue dissection is deeper with plates even though the incision is shorter. Medium-term clinical and radiological results were better in group 1, with a strong probability for wrist strength and radial inclination and a significant difference for palmar slope.

The main study hypothesis was confirmed: the incision scar left by minimally invasive internal fixation was smaller using MIPO than an intramedullary nail. Some of the secondary hypotheses were also confirmed: there were no differences between the two techniques in terms of pain at 6 months, QuickDASH, PRWE, range of motion or ulnar variance; two were not confirmed: pain at 6 weeks was less with intramedullary nails, and palmar slope was better with volar plates. In conclusion, the present findings showed that internal fixation of unstable extra-articular fracture in over 50-year-olds gave better clinical results at 6 weeks using an intramedullary nail, with fewer complications, while MIPO required shorter incisions.

Funding sources

None.

Authors' contribution

Maxence Thomas: reviewed the patients' follow-up.

Juan José Hidalgo Diaz, Guillaume Prunières, Sybille Facca: operated patients.

Yuka Igeta: reviewed the manuscript.

Philippe Liverneaux: participated in all the stages.

Table 7
Short- and medium-term results in 20 extra-articular distal radius fractures managed using the Initial R® plate (group 1) or Nail-o-Flex® (group 2).

Group (*n*)	Tourniquet time (min)	Pain (0–10)	QuickDASH (0–100)	PRWE (0–100)	Wrist strength, %	P, %						Passive range of motion (mm)	Palmar slope (°)	Ulnar variance (mm)
						F	E	UI	RI	P	S	Total		
Short-term median														
1	45.320 [29.325; 61.431]	3.591 [0.663; 7.942]	39.050 [8.496; 80.637]	43.142 [8.416; 83.923]	52.339 [34.346; 70.078]	77.860 [67.115; 89.053]	81.185 [69.486; 93.341]	85.933 [75.706; 96.754]	97.967 [82.991; 113.159]	99.560 [89.187; 110.587]	86.457 [75.715; 97.587]	13.461 [4.770; 22.245]	+10.546 [1.142; 19.950]	1.199 [−2.640; 0.271]
2	54.168 [40.741; 67.404]	1.744 [0.260; 5.223]	29.235 [6.614; 66.993]	28.582 [5.157; 65.672]	48.221 [33.942; 62.248]	78.092 [68.474; 88.445]	82.777 [72.618; 93.478]	87.433 [77.861; 97.211]	90.260 [78.020; 102.698]	107.280 [97.675; 117.132]	91.573 [82.028; 101.657]	31.760 [23.645; 39.761]	2.142 [−6.099; 10.404]	+0.198 [−1.440; 1.843]
Estimated difference	1.714	1.846	9.815	15.142	4,118	−0.232	−1.593	−1.5	7.707	−7.719	−5.116	−18.324	8.404	−1.397
Confidence interval	[−2.593; 25.593]	[0.177; 4.112]	[−7.602; 30.101]	[−3.368; 37.224]	[−9,455; 17,363]	[−10.950; 10.335]	[−13.302; 9.819]	[−12.004; 8.951]	[−6.658; 22.041]	[−18.271; 3.060]	[−16.050; 5.363]	[−22.538; −13.593]	[3.645; 13.067]	[−3.148; 0.372]
Probability of difference, %	89.6	99,1	86,1	94,2	73,4	48,7	40,0	38,6	85,5	7.6	17.4	99.9	99.9	5.7
Medium-term median														
1		0.849 [0.084; 3.296]	14.514 [1.839; 47.100]	17.084 [1.791; 53.061]	78.540 [58.664; 98.318]	91.863 [80.329; 103.980]	92.730 [79.736; 105.840]	92.373 [81.192; 103.641]	103.636 [85.520; 121.570]	97.315 [86.063; 109.043]	92.604 [81.303; 104.444]		10.388 [1.043; 19.868]	−1.101 [−2.539; 0.361]
2		0.759 [0.091; 2.741]	14.647 [2.492; 43.208]	14.307 [1.903; 42.490]	66.063 [49.206; 82.701]	85.762 [74.980; 97.432]	91.408 [79.782; 103.489]	89.719 [79.128; 100.532]	89.735 [74.434; 105.231]	105.656 [94.954; 116.909]	93.504 [82.628; 104.827]		2.690 [−5.538; 10.896]	0.026 [−1.599; 1.661]
Estimated difference		0.089	−0.134	2.777	12.477	6.226	1.307	2.720	2.720	−8.316	−0.809		7.697	−1.127
Confidence interval		[−0.691; 1.244]	[−13.272; 14.981]	[−10.276; 20.859]	[−4.201; 28.910]	[−6.459; 18.590]	[−12.982; 15.445]	[−9.970; 15.171]	[−9.970; 15.171]	[−21.145; 4.060]	[−13.726; 11.728]		[2.977; 12.357]	[−2.887; 0.635]
Probability of difference, %		56.1	44.2	63.4	93.3	83.7	57.2	67.1	92.9	9.1	45.2		99.8	10.0

%: % compared to contralateral side; F: flexion; E: extension; UI: ulnar inclination; RI: radial inclination; P: pronation; S: supination.

Disclosure of interest

Philippe Liverneaux has conflicts of interest with Newclip Technics, Argomedical, Zimmer Biomet, Biomodex.

The other authors declare that they have no competing interest.

Acknowledgment

Dr Sauleau Erik, pôle de santé publique, secteur méthodologie et biostatistiques, hôpitaux universitaires de Strasbourg, France.

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