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Technical note

Minimally invasive osteotomy for distal radius malunion: A preliminary series of 9 cases

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ABSTRACT

The rate of malunion after distal radius fractures is 25% after conservative treatment and 10% after surgery. Their main functional repercussion related to ulno-carpal conflict is loss of wrist motion. We report a retrospective clinical series of minimally invasive osteotomies. The series consisted of 9 cases of minimally invasive osteotomies with volar locking plate fixation. All osteotomies healed. The average pain was 5.3/10 preoperatively and 2.1/10 at last follow-up. The mean Quick DASH was 55.4/100 preoperatively and 24.24/100 at last follow-up. Compared to the opposite side, the average wrist flexion was 84.11%, the average wrist extension was 80.24%, the average pronation was 95.33% and the average supination was 93.9%. With similar results to those of the literature, our short series confirms the feasibility of minimally invasive osteotomy of the distal radius for extra-articular malunion.
Type: Case-series.
Level of evidence: IV.

1. Introduction

Malunion is a common complication of distal radius fractures. Their rate is estimated at 25% after conservative treatment and 10% after surgery [1]. Although the functional consequences are usually well tolerated, surgical correction may be indicated if ulno-carpal conflict or symptomatic loss of wrist motion occurs [2].

Different surgical procedures have been described for osteotomy fixation: pins, external fixators and recently locking plates [3–5]. For some authors, the bone loss caused by the osteotomy must be filled by bone [6], cartilage [7] or bone substitute [8]. Other authors consider bone filling useless [9]. Concerning the surgical approach, some authors advocate a dorsal approach [9], others lateral approach [3], and for most authors palmar approach according to Henry is the most appropriate [10].

We report a retrospective series of 9 cases of malunion of the distal radius treated with minimally invasive osteotomy with volar locking plate fixation.

2. Material and methods

Our study is a retrospective series of 9 osteotomies for malunion of the distal radius treated between March 2012 and February 2014 (Table 1). The mean age was 60 years. Eight patients were women. Seven fractures A2.2, A2.3 and one A3.2 were recorded [11]. Five fractures were previously treated with a cast, three by pins and one by pins and plate. All patients complained about pain and loss of motion (Table 2).

All patients were treated under locoregional anesthesia and tourniquet by 4 different senior surgeons.

Thanks to a minimally invasive Henry approach [12], the osteotomy was performed through the old fracture thanks to an osteotome under fluoroscopic guidance (Fig. 1). A locking volar plate was applied to the anterior aspect of the radial epiphysis (Step One®, NewClip Technics ™, Haute-Goulaine, France). After introduction of the osteotome and the jig under the pronator quadratus, the distal portion of the plate is stabilized on the watershed line thanks to two different pins, first one in the most ulnar hole, and second one in the most radial hole. Two aiming guides help the drilling of the two central holes. After drilling the two aiming guide are removed and the two central locking screws are inserted. Reduction of the malunion was then automatically obtained when the plate was locked on the radius shaft (Fig. 2). After inserting all

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Table 1
Casuistic.

Patient(N)	Gender(M/F)	Age(year)	Classification(AO)	Delay(month)	Dominant side(R/L)	Treated side(R/L)	Initial treatment
1	F	42	A2.2	60	R	R	Conservative
2	F	70	A2.2	11	L	L	Conservative
3	F	66	A2.3	36	L	R	K-wire
4	F	64	A2.2	?	R	R	Conservative
5	M	39	A3.2	3	R	R	Plate and K-wire
6	F	57	A2.2	9	L	R	K-wire
7	F	67	A2.2	76	R	R	K-wire
8	F	63	A2.2	7	L	R	Conservative
9	F	77	A2.2	2	R	R	Conservative

F: female; M: male; R: right; L: left; ?: preoperative data missing.

Table 2
Results.

Patient(N)	Flexion (%)		Extension (%)		Pronation (%)		Supination (%)		Grasp (%)		Pronation strength (%)		Supination strength (%)	
	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
1	100	94	83	92	80	86	100	93	50	88	54	47	33	58
2	73	50	84	18	100	100	93	100	33	40	13	30	33	50
3	83	94	100	108	100	86	100	93	80	88	100	120	75	83
4	62	75	85	100	90	100	95	94	92	111	80	100	70	85
5	50	60	50	52	70	85	80	90	50	60	70	85	70	70
6	87	100	62	75	92	94	44	75	50	69	85	100	78	70
7	62	87	42	67	100	100	82	100	19	67	20	50	18	67
8	59	82	50	110	76	100	83	100	27	71	37	62	58	50
9	73	115	130	100	88	107	107	100	45	14	90	46	46	100

Preop: preoperative; Postop: postoperative. Percentage (%) compared to opposite side.

the epiphyseal and diaphyseal screws, no interposition of the flexor tendons under the plate is assessed. No drainage was used after skin closure. No postoperative immobilization was prescribed.

Outcome evaluation was done intraoperatively with the measure of the radiation in cGy/cm^2, the duration of tourniquet in minutes and the scar size in millimeters. Postoperatively pain was assessed on a visual analogic scale from 0 (no pain) to 10 (worst pain imaginable) before surgery and at the last follow-up. The function of the hand was assessed by the Quick DASH score from 0 (normal function) to 100 (upper limb unusable) before surgery and at the last follow-up [13]. The mobility of the wrist (flexion, extension, pronation, supination) was assessed at the last follow-up compared to the opposite side as a percentage of contralateral side. The strength of grip was assessed using the Jamar® dynamometer scaled in position 2 (Sammsons Preston Ryolan™, Bolingbook, IL, USA) and compared to the opposite side as a percentage of the contralateral side. The prosupination strength was assessed and compared to the opposite side as a percentage of the contralateral side.

The statistical analysis with an alpha risk 0.05, was to compare the means of two quantitative matched values: the pain and the Quick DASH preoperatively and at the last follow-up. Since the series has few cases and the normality assumption is not verified we decided to use a nonparametric test. Also in the case of paired data (measures 2 times in the same subjects) a Mann-Whitney-Wilcoxon for paired data was used.

3. Results

The results are shown in Tables 2 and 3.

The average radiation was 2.5 cGy/cm^2. The average duration of tourniquet was 56 minutes. The average scar size was 17 mm with a range of 15 and 30. The average bone defect was 4.7 mm. The mean pain was of 5.3/10 preoperatively and 2.1/10 the last postoperative follow-up with a significant difference ($P = 0.022$). The average Quick DASH was 55.4/100 preoperatively and 24.24/100 at the last follow-up with a significant difference ($P = 0.014$). All the osteotomy healed, the average time of osteotomy healing was 5.22 months (3–8). Compared to the opposite side, the average wrist flexion was 72.11% preoperatively and 84.11% at the last follow-up. Compared to the opposite side, the average wrist extension was 76.22% preoperatively and 80.24% at the last follow-up. Compared to the opposite side, the average wrist pronation was 81.44% preoperatively and 95.33% at the last follow-up. Compared to the opposite side, the average wrist supination was 87.11% preoperatively and 93.9% at the last follow-up. Compared to the opposite side, the average wrist grasp was 49.55% preoperatively and 67.5% at the last follow-up. Compared to the opposite side, the average wrist pronation strength was 61% preoperatively and 71.11% at the last follow-up. Compared to the opposite side, the average wrist supination strength was 53.44% preoperatively and 70.33% at the last follow-up.

On radiographs, the average radial slope was −10.9° preoperatively and +4.5° at the last follow-up with a significant difference ($P = 0.021$). On radiographs, the average ulnar variance was +3.22 mm preoperatively and +0.33 mm at the last follow-up with a significant difference ($P = 0.018$).

4. Discussion

Some authors have developed minimally invasive approach to fix distal radius fractures [12,14,15]. Among advanced benefits, there are muscle and ligament attachments sparing, easier reduction and cosmetic aspects. There are two theoretical limits for a unique minimally invasive approach when treating a distal radius malunion: location of the incision, size and number of incisions.

Our results show that the location of the incision is not a limit for extra-articular malunion osteotomy. The average size of the incision in our series was 17 mm and in all our cases, we achieved osteotomy through this single incision. The only condition that should be considered is the incision should be centered on the future osteotomy line. The amount of irradiation in our series may be explained by the fact that operators were still in their learning curve. Concerning choosing between volar or dorsal approach, one may think it would depend on radial slope, other may think it

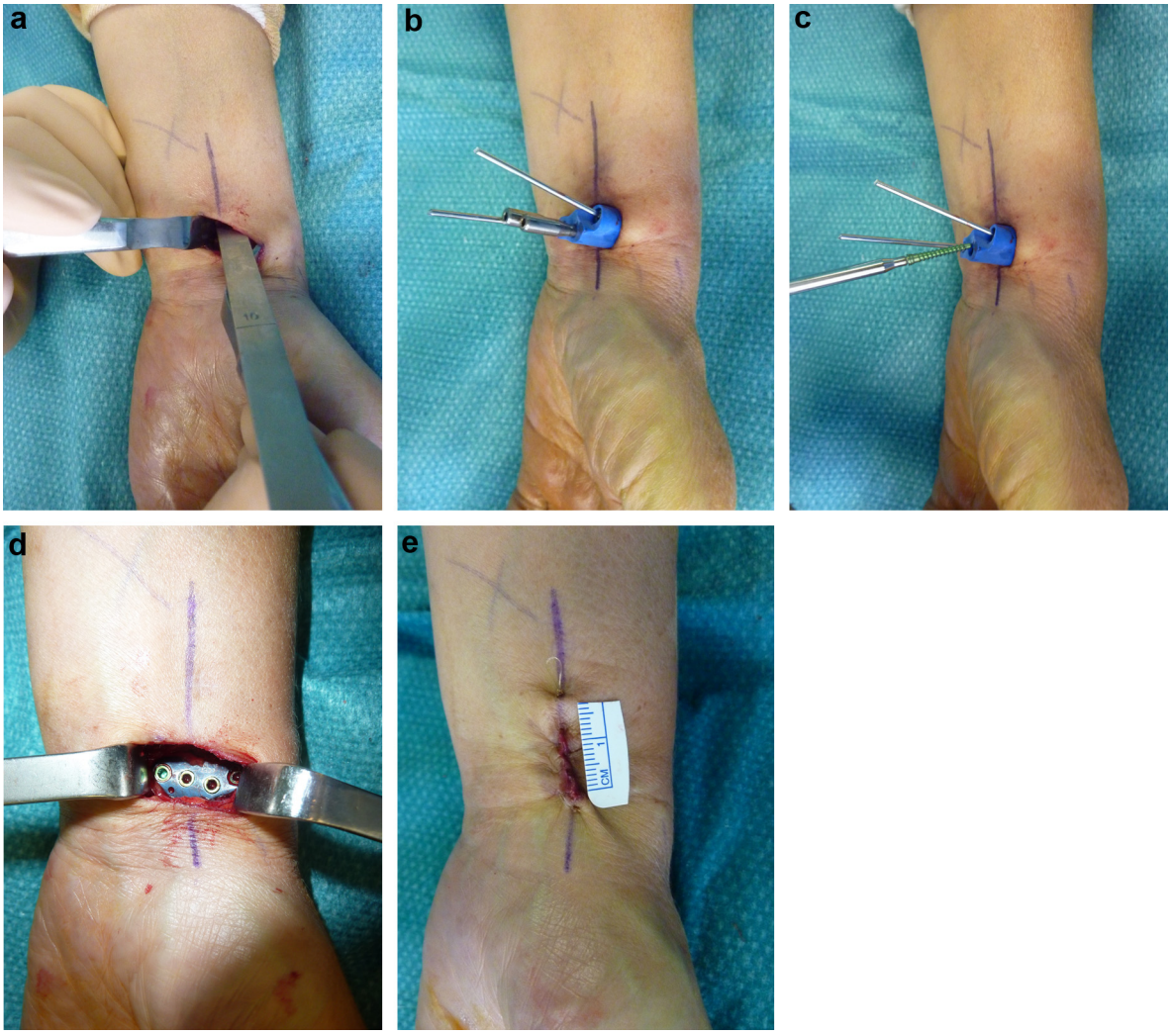

Fig. 1. Surgical technique for osteotomy of malunion of the distal radius with a minimally invasive approach: a: thanks to a minimally invasive Henry approach [11], the osteotome is placed in front of the old fracture line; b,c: after inserting all the epiphyseal and diaphyseal screws; d: no interposition of the flexor tendons under the plate is assessed; e: final aspect of skin incision.

would depend on the fixation device. In our series we always made a volar approach because we always proceeded to a circumferential osteotomy, thus no bone hinge was preserved.

Our results do not show whether it is possible to use this unique minimally invasive approach for complex articular malunion that often require extensive and multiple approaches. Our series included only two articular malunion that are unrepresentative to assess this unique minimally invasive approach.

Some authors advocate the interposition of a bone graft or bone substitute in the osteotomy [7,8]. We did not use it in our series. Three reasons can explain our decision: stability of the fixation, vascularization of the distal radius, and morbidity associated when bone is harvested. We do think that the filling of the osteotomy is useless when the bone is sufficiently stable. Volar locking plates allow stable bone fixation [16]. The high blood supply of the distal radius explains the very low rate of nonunion [17]. But, ideally a

Table 3
Results.

Patient(N)	Irradiation (cGy/cm^2)	Tourniquet time (min)	Scar (mm)	Healing delay (month)	Follow-up (month)	Pain (0–10)		Radial slope (°)		Ulnar variance (mm)		Quick DASH (0–100)	
						Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
1	5	85	20	4	5	6	0	−12	+5	0	−2	45.45	2.27
2	3.1	72	15	7	10	7	3	−20	+5	+5	+2	56.82	34.09
3	2.9	54	15	4	5	?	0	+30	0	+4	0	?	2.27
4	0.7	33	15	8	10	7	7	−10	+5	+2	0	56.82	50
5	1.2	31	30	4	5	3	0	−25	−10	0	−1	77.27	34.09
6	3.8	75	15	6	6	5	2	0	+15	+3	0	50	15.91
7	2.1	60	15	7	9	4	2	−12	+10	+3	+1	54.55	50
8	1.8	28	15	3	5	5	1	−17	+5	+4	+1	56.82	13.64
9	1.9	71	20	4	6	6	4	−32	+5	+8	+2	45.54	15.91

Preop: preoperative; Postop: postoperative; ?: preoperative data missing.

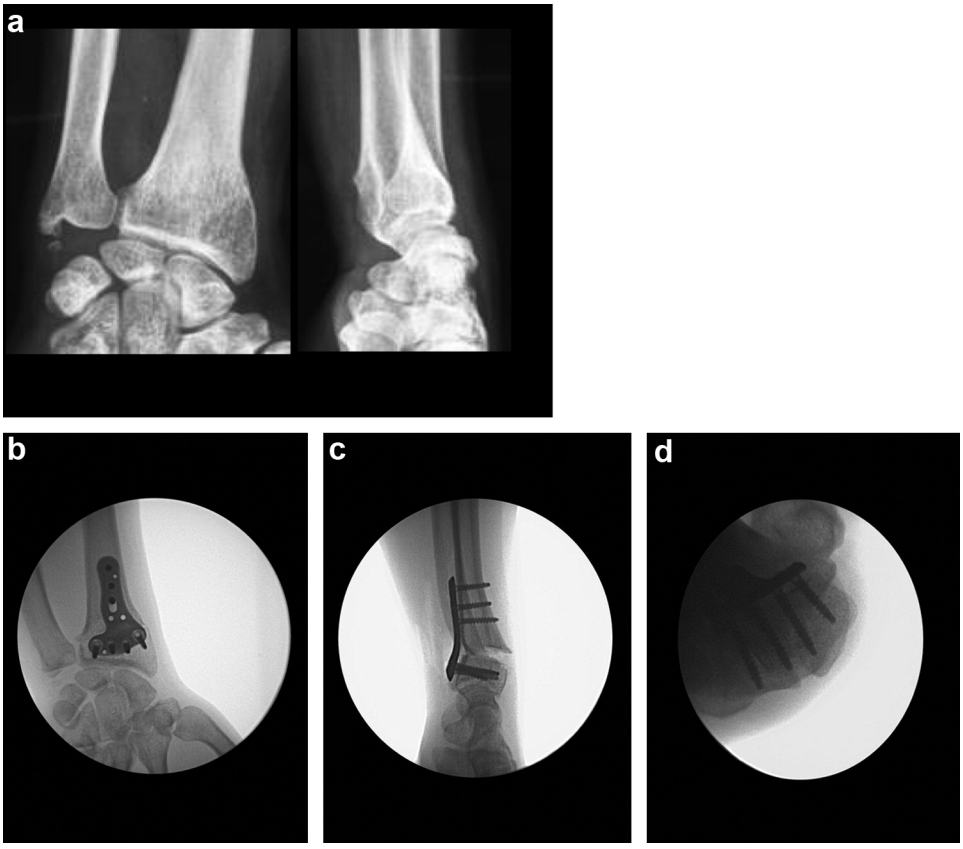

Fig. 2. Clinical case views: a: preoperative AP and lateral views; b: intraoperative fluoroscopic AP view. Notice the correction of the ulnar variance and the epiphyseal shift; c: intraoperative fluoroscopic lateral view. Notice the opening of the old fracture line with posterior sinus; d: intraoperative fluoroscopic skyline view. Notice that the epiphyseal screw does not exceed the posterior cortex of the radius and do not cross the distal radio-ulnar joint.

bone hinge should be maintained to preserve the periosteal blood supply. Morbidity at the harvesting site and the risks of general anesthesia and expected benefit of a bone graft must be weighed.

New trends are emerging for osteotomy planning osteotomy. Indeed several teams have developed customed guides from CTscan to fit perfectly each case [18]. This surgically demanding and expensive technique is probably useful for complex articular malunion. But, at the opposite, in extra-articular malunion with dorsal tilt, the anatomical shape of the locking plates is sufficient to allow anatomical reduction and stable fixation. No preoperative planning is required. To correct the ulnar variance and dorsal tilt, the only technical point the surgeon has to deal with is to respect the perfect match of the plate on the watersheld line. For us, distal radius osteotomy with a minimally invasive approach and no preoperative planning is only possible for extra-articular malunion. This aspect should be furthered with a larger series including articular malunion cases.

Despite the weaknesses of our retrospective series with short follow-up and only few patients, our results are similar to other series with conventional approaches published in the literature [2–4]. We do think it is possible to perform an osteotomy of the distal radius with a minimally invasive approach without bone grafting or complex preoperative planning. Nevertheless, the results should be confirmed with a bigger comparative series and a longer follow-up.

Disclosure of interest

Philippe Liverneaux has conflicts of interest with Newclip Technics, Integra, Argomedical, iiN medical.

The other authors declare that they have no conflicts of interest concerning this article.

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