Orthopaedics & Traumatology: Surgery & Research (2011) **97**, 471—478

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ORIGINAL ARTICLE

Dorsally displaced extra-articular distal radius fractures fixation: Dorsal IM nailing versus volar plating. A randomized controlled trial

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Accepted: 15 November 2010

KEYWORDS
Distal radius;
Volar plate;
Dorsal nail

Summary

Introduction: Fractures of the distal radius are very common and mainly occur in the elderly. There has been an increasing use of locked volar plate fixations which report satisfactory results. However, some authors advocate the use of nail fixation.

Hypothesis: The aim of this study is to compare dorsal nail plate versus locked volar plate fixation in the treatment of distal radius fractures with dorsal tilt.

Materials and methods: The mean age of the patients was over 50 years. The study included extra-articular distal radius fractures with posterior tilt. We conducted a prospective randomized study between December 2007 and February 2009 including a group of 16 patients treated with a dorsal nail fixation (group 1) and a group of 15 patients managed with a locked volar plate fixation (group II). We analyzed both the clinical results (complications, Range of motion [ROM], tightening strength, Disabilities of the Arm, Shoulder and Hand [DASH] and Mayo Clinic scores) and the radiographic results from A/P and lateral radiographs in the early postoperative period and at 6-month follow-up.

Results: ROM toward extension was better in the volar plating subgroup (group I, 42.5°, group II, 57.5°; $P < 0.05$). Pronation mobility was better in the dorsal nail subgroup (group I, 85°; group II, 80°; $P < 0.05$). The locked volar plate fixation subgroup demonstrated a better recovery of the tightening strength as compared with the uninjured side (group I, 78%, group II, 90%, $P = 0.03$). The DASH score was similar in both groups (group I, 22.09 ± 22.9; group II, 20.62 ± 20.3, $P > 0.05$). The Mayo Clinic score was better in the locked volar plate fixation subgroup (group I, 65 ± 13.4; group II, 85.6 ± 19.2; $P = 0.002$). Radiographic results were good in both groups, however anatomical reduction of the volar tilt was significantly better in group II (plate) when compared with the uninjured side. Moreover, we report on two cases of tendinous damages to the long extensor muscle of the thumb in the dorsal nail fixation subgroup despite the use of a minimally invasive implant.

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doi:10.1016/j.otsr.2010.11.011

Conclusion: The management of distal radius fractures with locked volar plate fixation in active elderly patients has proved successful and leads to better results than nail fixation regarding both reduction quality and objective functional scores.
Level of evidence: Level II, prospective, randomized of low-level.

Introduction

Fractures of the distal radius are very common since they account for 20% of all fractures [1]. These fractures occur in two different age categories: the young and the elderly. There is an increasing use of the locked volar plate fixation in the elderly since it provides a better reduction and stability and allows early mobilization. Moreover, this technique reports a lower risk of tendinous damage compared with dorsal plates due to the plate coverage by the pronator quadratus muscle. Biomechanical studies report a similar implant stiffness compared with dorsal plates [2—8], thus allowing 100 and 250 N load transmitted to the wrist during active mobilization of the wrist and fingers respectively, to be absorbed [7].

However, since the volar approach requires significant soft tissue dissection, new intramedullary implants have been developed to be inserted through a minimally invasive approach. Among these implants, the Distal Nail Plate (DNP®, Hand Innovations, Miami, Florida) is a hybrid implant featuring a distal posterior plate associated with a proximal intramedulary section [9,10]. Its small size compensates for its insertion through a dorsal approach. Biomechanically, it has a similar stiffness to that of the volar plate [6].

We compared this new implant with the locked volar plate which is the current reference system.

Material and methods

We present a prospective randomized study, conducted in the Department of Orthopaedic and Trauma Surgery of the Brugmann Hospital Center (Brussels) which protocol was submitted to the approval of our institution Ethics Committee and was approved. This protocol compares the dorsal nailing fixation (DNP, Hand Innovation, Miami, Florida) with the locked volar plate (Dorsal Volar Radial [DVR®], Hand Innovation, Miami, Florida) and includes two groups of 16 and 15 patients, respectively operated on between December 2007 and February 2009. Only patients of more than 50 years of age, who sustained an extra-articular distal radius fracture with dorsal tilt, of type I, II, V or VI according to the classification of Frykman [11] were included. Fractures were also classified according to the Arbeitsgemeinschaft Osteosynthese (AO) classification in order to compare our series with those already published in the literature.

We used a 10 random quote using pre-established and mixed envelops, patients being randomly allocated on admission.

Patients with a history of trauma to the injured wrist as well as those with advanced dementia were excluded.

On admission, each patient was clinically evaluated and radiographically examined using AP and lateral radiographs of the wrist for fracture classification and radiographic measurements.

All patients were operated on by the same operator (Dr Philippe Bouté). The type of anaesthesia was selected in accordance with the anaesthesist's preference. In most cases, a locoregional anaesthesia was chosen. Patients were placed in the supine position with the operated upper limb resting on an arm support. A tourniquet was placed at the proximal part of the operated limb. Surgery was performed under image intensification.

Patients from group I were managed with a DNP nail fixation® inserted through a dorsal approach and centered over the Lister tubercle (Figs. 1 and 2). Patients from group II were managed with a DVR locked volar plate fixation® placed through a Henry type volar approach (Figs. 3 and 4). Early postoperative mobilization of the wrist was allowed in all cases.

Patients were then reviewed during follow-up visits and at last follow-up (6 months) by an examiner different from the operator (Dr Julien Chappuis). During the follow-up period, radiographs were taken at 3 and 6 weeks, 3 and 6 months for measurement of the Laugier angle (or inclination of the AP articular surface), the volar tilt and radio-ulnar index.

During the follow-up visits, patients were examined to record the range of movements, the tightening strength of the healthy and injured sides using a Jamar® dynamometer (Sammons Preston Rolyan, Bolingbrook, IL, USA) and the occurrence of potential complications such as neural deficit, algodystrophy or tendinous damage.

At 6-postoperative months, a subjective and objective functional evaluation was performed based on the Disabilities of the Arm, Shoulder and Hand (DASH) [12] and Mayo clinic scores respectively.

Residual pain assessment was made using a VAS scale.

Figure 1 Distal Nail Plate (DNP®) nail.

Figure 2 Postoperative radiograph of nail fixation.

Figure 4 Postoperative radiograph of volar plate.

Our results were analyzed using an Excel® programme and the Minitab® statistical software (version 0.5, Minitab Inc., State College, Pennsylvania). We first used the Anderson-Darlin normality test for all data analysis in order to check their Gaussian distribution and select the most appropriate statistical test.

The Student *t* test and Pearson's Chi^2 test were used to compare the overall data from both groups (age, gender, dominant side, classifications). The Kruskal-Wallis test enabled us to compare clinical and radiographic measurements but also scores from both groups. The Mann-Whitney test was used to compare the results within each group. The threshold value for statistical significance was set to $P < 0.05$.

Results

We have collected all necessary data at 6 postoperative months for the 31 patients included in the study, with no patient lost to follow-up.

Figure 3 Volar plate.

The overall data regarding the population of patients are reported in Table 1.

Regarding their professional activity at the time of trauma, 12 were retired and four still active in group I whereas 12 were retired and three still active in group II. Among the active patients from group I, there were two secretaries and two administrative workers. In group II, two active patients were cleaning operatives and one was a secretary.

All retired patients were physically active (mainly gardening, sewing and sporting activities) and/or autonomous.

Once standard radiographs were analyzed on admission, patients' fractures could be recorded according to the Frykman classification. Therefore seven type I, five type II and four type VI fractures were recorded in group I and seven type I, five type II, 1 type V and two type VI fractures were recorded in group II according to the Frykman classification ($P = 0.946$).

According to the AO classification, there were 12 A2 and four A3 fractures in group I whereas there were 10 A2 and five A3 fractures in group II ($P = 0.93$).

The results obtained from radiographic measurements in both groups are reported in Tables 2 and 3.

Early postoperative measurements were made on early postoperative radiographs whereas late measurements were performed on 6-postoperative month radiographs. Regarding volar tilt, a significant difference could be observed between group I and group II for immediate postoperative values and six months postoperative values ($P = 0.012$ and $P = 0.05$ respectively) in favor of group II demonstrating a better restoration. However, there was no significant difference between the two groups regarding the Laugier angle when measured during the early postoperative period or at 6 months ($P = 0.234$ and $P = 0.797$, respectively). No significant difference could be found between the two groups regarding the radio-ulnar index in the early postoperative period whereas there was a significant difference at 6 months ($P = 0.087$ and $P = 0.002$, respectively) in favor of group II even if the mean values observed in both groups remain within the normal limits (0 mm ± 2).

Table 1 Overall data regarding the studied population.

	Patients (*n*)	Mean age (years)	Gender (F/M)	Dominant side
Group I (nail)	16	71.69 ± 11.2	14/2	9
Group II (plate)	15	71.73 ± 13.6	13/2	7
Difference	NS	NS	NS	NS

S: significant difference, NS: no significant difference.

Table 2 Radiographic measurements from group I, managed by dorsal nail.

	Volar tilt	Laugier angle	Radio-ulnar index (mm)
Preop	−26°	16.63°	3.7
Postop	−2.06°	22.5°	1.2
Postop versus preop difference	S	S	S
6 months	−1.19°	23.4°	2.02
6-month versus postop difference	NS	NS	NS
Healthy side	10.06°	24.18°	0.97
Healthy side versus 6-month difference	S	NS	NS

S: significant difference, NS: no significant difference.

Table 3 Radiographic measurements from group II, managed by volar plate.

	Volar tilt (°)	Laugier angle (°)	Radio-ulnar index (mm)
Preop	−19	16.27	1.5
Postop	7.8	24.26	0.23
Postop versus preop difference	S	S	NS
6 months	7.47	23.8	0.42
6-month versus postop difference	NS	NS	NS
Healthy side	9.13	25.2	0.43
Healthy side versus 6-month difference	NS	NS	NS

S: significant difference, NS: no significant difference.

The range of motion (ROM) and tightening strength results are reported in Table 4.

Regarding the tightening strength, expressed in percentage of recovery relative to the healthy side, a 78% recovery was observed in group I versus 90% in group II, such significant difference being in favor of group II ($P = 0.03$).

The DASH questionnaire analysis did not demonstrate any difference between the two groups with a mean score of

Table 4 Range of motion (ROM) and tightening strength.

	Group I			Group II		
	Mean values (extremes)			Mean values (extremes)		
	Injured	Healthy	Difference	Injured	Healthy	Difference
Extension	**42.5°** (31.25–60)	57.5° (50–70)	S	**50°** (40–80)	60° (50–80)	NS
Flexion	62.5° (47.5–75)	75° (65–85)	S	60° (50–80)	70° (50–85)	NS
Pronation	**85°** (80–85)	85° (81.25–85)	NS	**80°** (80–80)	80° (80–80)	NS
Supination	80° (63.75–85)	85° (81.25–90)	NS	80° (50–90)	80° (70–90)	NS
Ulnar inclination	40° (30–48.75)	40° (40–53.75)	NS	30° (20–40)	30° (25–40)	NS
Radius inclination	15° (10–15)	15° (11.25–15)	NS	10° (10–15)	10° (10–15)	NS
Tightening strength	35.5 kg(15.75–53.75)	45 kg(24.75–59.75)	NS	18 kg(10–20)	20 kg(18–30)	NS

S: significant difference; NS: no significant difference; for values, **in bold letters**, a statistically significant difference was observed on the injured side between the two groups.

Table 5 Postoperative complications in our series.

Complications	Group I	Group II
Infection	0	0
Haematoma	0	0
Material breakage	0	0
Neural deficit	0	(1)
Vascular damage	0	0
Tendinous damage	2	0
Algodystrophy	2	1
Carpal tunnel syndrome	0	1

22.9 ± 20.9/100 in group I with extremes values ranging from 0 to 55 and 20.62 ± 20.3/100 in group II with extreme values ranging from 0 to 59 ($P = 0.89$).

Analysis of the Mayo Clinic scores revealed a significant difference in favor of group II ($P = 0.002$). The mean score achieved was 65 ± 13.4/100 in group I with extreme values ranging from 35 to 90 and 85.6 ± 19.2/100 in group II with extreme values ranging from 25 to 100.

Complications are reported in Table 5.

There were two cases of tendinous damages to the long extensor muscle of thumb in group I. These patients were managed by tendon transfer of the extensor muscle of index finger. Their functional evolution was unfavorable regarding the DASH and Mayo clinic scores despite a satisfactory ROM. Moreover, two cases of algodystrophy were reported in group I and one case in group II thus requiring an additional calcitonin treatment. Their functional evolution was unfavorable regarding the DASH and Mayo clinic scores but also the ROM.

Discussion

Our prospective study has a small sample size (16 patients in group I and 15 in group II). However, the existing literature shows that studies published on nail fixation of distal radius fractures, two of which being prospective, had 10 to 27 patients enrolled [10,13,14] while those published on volar plate fixation, six of which being prospective, had 23 to 61 patients enrolled [15–23]. Patients enrolled in these studies had extra- and intra-articular distal radius fractures. When only taking into account patients with extra-articular fractures in these series from the literature, which corresponds to A2 or A3 distal radius fracture in our series, the patient cohort ranges from six to 21 patients in the dorsal nail fixation group and one to 27 patients in the volar plate fixation group. Our series is thus comparable to those published in the literature regarding the sample size.

When taking into account the age of the patients, our cohort is comparatively older since the mean age of the patients in our series is 71.69 in group I and 71.73 in group II. This is due to the inclusion criteria which only retained patients aged more than 50 years. In series from the literature, the mean age of the patients is commonly younger due to the absence of age-related inclusion criteria (from 53 to 60 years). In a study conducted by Kaba et al. [10], on nail fixation, the mean age of the patients was 71.7 years. In studies conducted by Orbay et al. [16] and Chung et al. [23], on volar plate fixation, the mean age of the patients was 78.6 and 68.9 years, respectively.

The comparison of radiographic data is reported in Tables 6 and 7.

When comparing the results from group I (nail) with those achieved in the series of Kaba et al. [10] using the same implant, volar tilt restoration appears less satisfactory in our series. However, as these authors, we do not report any progressive loss of reduction. In two series using the micronail® [13,14], a poorer volar tilt restoration was observed. According to Ilyas et al. [13], this implant may have some limitations in case of major dorsal comminution and should be compared with volar plate fixation. Brooks et al. [14] only report three cases of loss of reduction in patients with B3 and C2 fractures. Ilyas et al. [13] only report two cases of loss of reduction in patients with A3 fractures associated with volar tilt which evolves from 0° to −20° and from 0° to −7°, respectively.

Our results correlate those published in the literature on volar plates. Restoration of volar tilt is better than that observed with nail fixations. There is no loss of reduction unlike reported in isolated cases by several authors. Orbay et al. [16] describe three cases of shortening with a 1, 2 and 2 mm loss but no details are given about the fracture types. Wong et al. [18] find a loss of reduction in one case associated with a 7° loss of volar tilt and a 2 mm radius shortening in a patient with a C3 fracture. Rozental et al. [20] report four cases of loss of reduction of the volar tilt in two patients with A3 fractures, one patient with C2 fracture and one patient with C3 fracture. In our study, a better volar tilt restoration and a better preservation of the radius length are observed in the volar plate fixation subgroup.

The DASH scores in our series are reported in Table 8.

These results are similar in the two groups and correlate those observed in the literature.

The ROM and tightening strength results in our series are reported in Table 9.

All these measurements were made at 6 months postoperatively. In group I, a significant flexion-extension deficit is found relative to the healthy side which might result from

Table 6 Preop, postop and last follow-up radiographic measurements in series using a dorsal nail fixation.

	Volar tilt (°)			Laugier angle (°)			Radio-ulnar index (mm)		
	Preop	Postop	Last followup	Preop	Postop	Last follow-up	Preop	Postop	Last follow-up
Kaba et al. (2006) [10]	−30,6	11.4	11.4	15.3	24.6	24	4	0.5	0.6
Brooks et al. (2006) [14]	> −20	5	5	–	22	22	> 5	0	0
Ilyas et Thoder(2008) [13]	> −15	2.2	2.2	–	24.1	24.1	> 2	−0.6	−0.6
Our series	−26	−2.06	−1.19	16.63	22.5	23.4	3.7	1.2	2.02

Table 7 Preop, postop and last follow-up radiographic measurements in series using a volar plate fixation.

	Volar tilt (°)			Laugier angle (°)			Radio-ulnar index (mm)		
	Preop	Postop	last follow-up	Preop	Postop	Last follow-up	Preop	Postop	Last follow-up
Kamano et al. (2002) [15]	−23	–	9	18	–	24	3	–	1
Orbay et al. (2004) [16]	−23	5	5	11	20	20	4	0	0
Musgarve et Idler (2005) [17]	−20	2	2	16	24	23	–	–	–
Wong et al. (2005 [18]	−19	5	5	16.6	22	22	3	1	1
Cognet et al. (2006) [19]	–	4.65	4.65	–	24.88	24.8	–	−0.24	−0.2
Rozental et al. (2006) [2]	–	4	5	–	21	21	–	–	–
Pichon 2008) [21]	−25	5.45	5.45	13	24	24	4.18	0.78	0.78
Chung et al. (2008) [23]	> 10	9	8	< 15	25	24	> 2	0.6	0.2
Osada et al. (2008) [22]	−23	9	9	16	22	22	4	1	1
Our series	−19	7.8	7.47	16.27	24.26	23.8	1.5	0.23	0.24

Table 8 Comparison of Disabilities of the Arm, Shoulder and Hand (DASH) scores.

	Mean DASH
Brooks et al. (2006) [14]	8
Ilyas et Thoder (2008) [13]	8.1
Our series group I (nail)	22.09
Orbay et al. et al. (2004) [16]	8.28
Cognet et al. et al. (2006) [19]	20.6
Rozental et al. et al. (2006) [2]	14
Pichon et al. et al. (2008) [21]	38.4
Osada et al. et al. (2008) [22]	6
Our series, group II (plate)	20.62

the use of a dorsal approach known to induce restricted ROM. This phenomenon was also pointed out by Kaba et al. [10]. On the other hand, series using the micronail implant® [13,14] inserted through a styloid approach report the same flexion-extension limitation. In group II, the restored ROM is not significantly different from that of the healthy side. Our values correlate those reported in the literature. A better recovery of the tightening strength is observed in group II when expressed in percent of strength in comparison to the healthy side. Such a difference is less significant in the literature.

In group I, tendinous complications could be observed which consisted in two cases of tendon tears of the long extensor muscle of the thumb. These two patients were managed by tendon transfer of the extensor muscle of index finger. However, their DASH and Mayo clinic scores demonstrated an unfavorable functional evolution. These tendinous complications have not been described by Kaba et al. [10] and Orbay et al. [16]. But nevertheless, the DNP implant® was known to be mini-invasive, resulting in a lower rate of tendinous damages.

Two cases of algodystrophy were observed in our series (12.5%) which functional evolution was unfavorable. Kaba et al. [10] also report one case of algodystrophy (3%) whereas Brooks and Ilyas do not report any case of that specific complication [13,14].

Both authors describe three and two cases respectively of paresthesia in the superficial sensory radial nerve territory that resolved spontaneously [13,14].

Ilyas et al. [13] also report three cases of epiphyseal screw penetration into the distal radio-ulnar joint resulting in a symptomatic distal radio-ulnar arthrosis in one case.

Table 9 Comparison of Range of motion (ROM) and tightening strength.

	Flexion	Extension	Pronation	Supination	Radius inclination	Ulnar inclination	Tightening strength (%)
Kaba et al. (2006) [10]	46	40	68	77			
Brooks et al. (2006) [14]	58	73	87	78	22	28	80
Ilyas et Thoder (2008) [13]	67	71	85	82	23	38	91
Our series, group I (nail)	62.5	42.5	85	80	15	40	78
Kamano et al. (2002) [15]	60	63	73	83			
Orbay et al. (2004) [16]	55	58	80	76	13	26	77
Wong et al. (2005) [18]	55	59	82	98			68
Cognet et al. (2006) [19]	64	69	79	72	17	34	
Rozental et al. (2006) [2]	52	53	73	71			94
Osada et al. (2008) [22]	66	75	78	88	23	37	99 and 85
Our series, group II (plate)	60	50	80	80	10	30	90

ROM are expressed in degrees; tightening strength expressed in % compared with the healthy side

One case of algodystrophy was observed in group II of our series (6.6%) which functional evolution was unfavorable. Among the reviewed series, several authors [17,19,21] also report similar cases of algodystrophy which rate of occurrence ranges from 4.34 to 18.18%.

A carpal tunnel syndrome was noted in one case of our series at 3 months (6.6%), and was confirmed by electromyography. This case was managed by surgical decompression with no adverse effect on functional recovery. In the reviewed series, other authors [17,18,21] also report similar cases which rate of occurrence ranges from 3.12 to 6.06%.

Tendinous lesions after volar plate fixation were also described in the literature [24—29]. However, no similar cases were observed in our series. In all cases, these tendinous lesions were induced by the use of screws of an excessive length with effraction involving the dorsal cortex of the radius. Moreover, we should be aware of the additional risks related to the use of our plate. Such risks include a drill-guide left in place after being pre-assembled to the plate which could lead to tendinous lesions [30].

Conclusion

The treatment of distal radius fractures with locked volar plate fixation in active elderly patients has proved successful and leads to better results than nail fixation regarding both reduction quality and objective functional scores. The occurrence of two tendinous lesions related to the use of a nail fixation technique points out the need to further improve this type of fixation. We thus recommend the use of locked volar plates in daily practice as a reliable method of treatment of extra-articular fractures of the distal radius.

Disclosure of interest

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

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