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Original article

Dorsal approach and internal fixation of impacted intra-articular distal radius fractures with 2.4 mm locking plates

Abord dorsal des fractures intra-articulaires avec enfoncement articulaire de l'extrémité distale du radius et ostéosynthèse par plaques 2,4 mm verrouillées

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Abstract

The treatment of impacted distal radius fractures is complex. Internal fixation by a dorsal approach with arthrotomy should be considered, particularly when the fractures are dorsally comminuted. This was a retrospective, observational study of 26 patients operated between 2008 and 2012 who were reviewed in September 2013. In the surgical procedure, a single dorsal incision was made over the distal radius and arthrotomy performed; the fracture site was stabilized with two 2.4 mm locking plates. The average follow-up was 39 months. All fractures were type 23C in the AO classification. All patients were assessed with the QuickDASH and Mayo Wrist scores. Total range of motion was 82% of the contralateral side. Grip strength was 30 kg in average. The mean radial sagittal tilt was +6° postoperatively. No plate movement or intra-articular screws were present. Four patients developed symptomatic early osteoarthritis. Thirteen patients had the plate removed due to discomfort. No tendon ruptures were observed. The dorsal approach remains a treatment option for specific intra-articular fractures. It offers direct intra-articular congruency control, along with a stable buttress and locking fixation for early mobilization. Our results are comparable to those using other surgical techniques for this type of high-energy fracture.

Keywords: ORIF; Distal radius; Dorsal approach; Intra-articular; Articular impaction

Résumé

L'ostéosynthèse des fractures de l'extrémité distale du radius avec enfoncement articulaire est difficile. La fixation interne par abord dorsal avec arthrotomie devrait encore être envisagée, surtout lorsque l'atteinte est principalement dorsale. Il s'agit d'une étude rétrospective observationnelle non comparative de 26 patients opérés entre 2008 et 2012 et revus en septembre 2013. La technique chirurgicale utilisait un : abord longitudinal dorsal unique avec arthrotomie et une ostéosynthèse par deux plaques dorsales 2,4 mm à vis verrouillées. Le suivi moyen est de 39 mois. Toutes les fractures sont de type 23C selon la classification de l'AO. Tous les patients étaient évalués par les scores QuickDASH et Mayo Wrist Score. Les valeurs moyennes de la flexion–extension sont 37-0-54° et l'arc de mobilité complète était de 82 % par rapport au côté opposé. La force de la poigne était de 30 kg en moyenne. La pente radiale sur le cliché de profil était de +6° en moyenne. Il n'y eut pas de déplacement secondaire du matériel ni de vis intra-articulaire. Chez quatre patients, est apparue une arthrose précoce symptomatique. L'ablation du matériel d'ostéosynthèse a été faite chez 13 patients. Il n'y a pas eu de rupture tendineuse. L'abord dorsal reste à envisager lors de fractures intra-articulaires spécifiques. Il permet la correction de l'incongruence articulaire sous contrôle visuel direct. L'effet console et les vis verrouillées offrent la stabilité pour la mobilisation rapide. Quinze pour cent développent une arthrose précoce. Nos résultats correspondent à ceux des autres techniques chirurgicales pour ce type de fracture à haute énergie.

Mots clés : Ostéosynthèse ; Extrémité distale du radius ; Intra-articulaire ; Abord postérieur ; Enfoncement articulaire

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1. Introduction

Distal radius fractures make up more than 17% of all fractures [1]. Internal fixation is being used more and more to provide surgical stabilization and good results have been reported. However, there is no international consensus as to the preferred technique for treating distal radius fractures [2,3]. Surgical treatment provides anatomical and stable reduction of the fracture and articular surfaces, which prevents secondary displacement, while allowing early mobilization to avoid stiffness. A volar approach and internal fixation with a volar plate are used the most, but in some cases, it can be difficult to correctly stabilize a dorsal comminution [4,5]. In addition, the surgeon cannot directly look at the radiocarpal joint when using a volar approach. However, it is essential to visually inspect this area to ensure joint congruence and to avoid secondary complications [2]. Since the resolution of intraoperative fluoroscopy is not good enough [6,7], arthroscopy [6–9] or arthrotomy can be performed instead. One of the advantages of the dorsal approach is that the comminuted area and posteriorly displaced fracture can be approached directly. An arthrotomy makes it possible to directly inspect the radiocarpal articular surfaces at the same time [4,10–13]. In addition, the buttress effect of the dorsal plates increases the construct's stability.

The purpose of this non-comparative, retrospective study was to document the medium term results after open reduction and internal fixation (ORIF) through a dorsal approach of comminuted intra-articular impacted fractures that have little volar involvement. The goal was to determine if it was justified to continue including this surgical technique in the treatment arsenal for these specific intra-articular wrist fractures.

2. Material and methods

2.1. Surgical technique and follow-up

A single longitudinal incision over Lister's tubercle was made on the dorsal side of the wrist. After opening the extensor retinaculum between the 3rd and 4th extensor compartments, the posterior interosseous nerve was divided to partially denervate it. By lifting the fracture's dorsal hood, it was possible to see inside the joint; an additional transverse arthrotomy was performed while preserving the dorsal radio-triquetral ligament. Lister's tubercle was resected in most cases and was used as bone autograft material when needed. We then reduced the fracture and restored the joint's congruence under direct visual control. Depending on the size of the bone defect, bone allograft granules (Allobone®, Neutromedics™) were added and impacted to blend in with the defect. The fracture site was stabilized with two titanium variable angle 2.4 mm plates (2.4 mm LCP Distal Radius System, Depuy Synthes™) according to the technique described by Rickli and Regazzoni [14]. The first plate was aligned so as to fix the ulnar column of the distal radius, and the second was placed between the 1st and 2nd extensor compartments to secure the radial column of the distal radius. The joint capsule and extensor retinaculum were closed using interrupted, absorbable sutures. Patients remained in the hospital for 24 to 48 hours following the procedure.

A short volar cast was added 24 or 48 hours later and worn for up to 4 weeks; the site was then protected with a thermoplastic splint and progressive mobilization was started. The mobilization was done without forceful movements for 2 months postoperative.

During the postoperative phase, all patients underwent the typical clinical and radiological follow-up after surgical fixation of a distal radius fracture in our hand surgery unit; after the day 2 evaluation, follow-up visits were at 2, 6 and 12 weeks, then 6 months and 1 year; pure A/P and lateral X-rays were taken without deviation. Preoperatively, some patients also underwent a CT scan.

The fixation plate was removed in the patients who complained of discomfort. An ultrasound was performed when this discomfort was subjective. The hardware was removed through the same incision as the one used for ORIF.

2.2. Study design and patients

We carried out a retrospective, non-comparative observational study of 26 patients that was approved by our hospital's ethics committee. In all, 47 patients were operated by four senior hand surgeons in our hand surgery unit between 2008 and 2012. The surgical indication in every case was discussed by the hand surgery team. A full review of the medical records was done for the primary analysis of the clinical and radiological results. A clinical review of 26 patients was carried out in September 2013. This article only pertains to the results obtained in these 26 patients. The records of the non-reviewed patients were studied to ensure there was no selection bias. The results were also analyzed by the medical statistics team. There were no exclusion criteria.

The medical records included the clinical values for flexion–extension and pronation–supination (in degree) along with two strength tests. Pinch strength (kg) was measured using the key pinch test. Grip strength was measured with a Jamar® dynamometer. Both the operated and non-operated sides were tested. The type of imaging performed was recorded (standard pure A/P and lateral X-rays without deviation and CT scan) and these images were analyzed by two different surgeons. All patients had intra-articular impacted fractures with little or no volar metaphyseal or epiphyseal involvement. The fractures were classified using the AO classification [15] by the surgeon and the first author. These were all type 23C fractures in the AO classification, with the following subtypes: C1 in 2 cases, C2 in 12 cases, C3 in 12 cases. Fig. 1a and b are an example of the standard preoperative X-rays performed in one of the reviewed patients.

The correction between the pre- and postoperative images was measured for the anatomical distal radius angles and joint congruence. The chosen standards for anatomical angles of the distal radius [16] were a slope of +11.2° (± 4.6°) on the lateral view and radial inclination of 23.6° (± 2.5°) on the A/P view. The chosen standard for the distal radio-ulnar index was +2 mm to −2 mm. Incongruity, and in particular joint step-off, was

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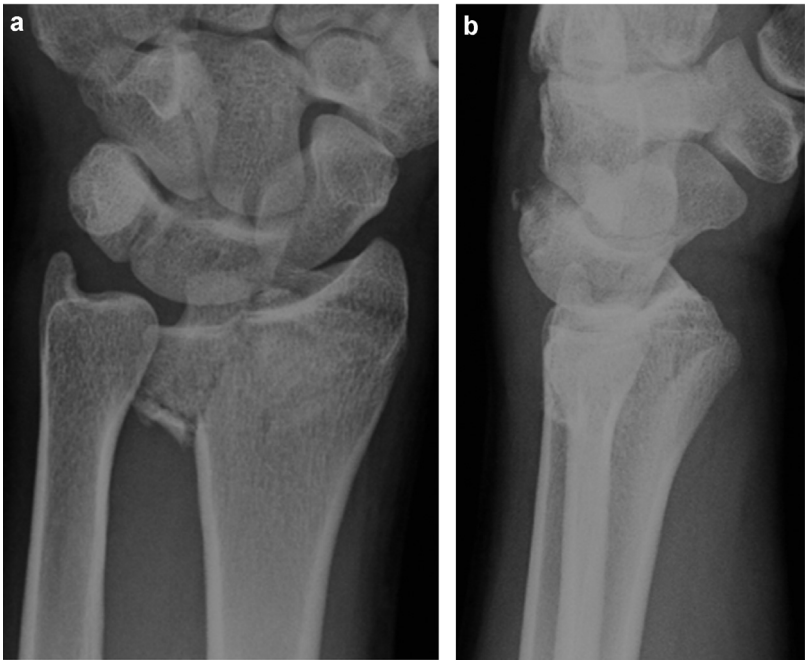

Fig. 1. Preoperative X-rays. A/P radiograph showing damage to the radiocarpal and distal radio-ulnar joints (a). Standard lateral radiograph showing an intra-articular distal radius fracture with dorsal triquetral ligament detachment; VISI also possible (b). The same patient's case is featured in all the figures that follow.

measured in millimeters pre- and postoperatively. This was done on the CT scan images, when available (Fig. 2a and b). Any radiological signs of post-traumatic osteoarthritis (subchondral sclerosis, subchondral cyst, osteophytes, joint space narrowing) were noted.

The date of the primary surgery and removal of the volar plate (if done) were taken from the patient's medical records. The age, gender and dominant hand of the 26 patents was documented. We recorded if the dominant hand had been operated on. Pain on a Visual Analog Scale (VAS) [17] and the subjective QuickDASH [18,19] and Mayo Wrist Score [20] were determined. Return to work at pre-injury levels or in another position was noted. The SANE [21] score, which describes the patients' feelings when answering the question ''What percentage of your overall wrist function do you have right now?'' was also noted; up to now, this score had been used to follow-up patients undergoing shoulder surgery.

Objectively, the range of motion in flexion, extension, radial and ulnar deviation and pronation–supination, along with the grip and pinch strength were recorded. The QuickDASH and Mayo Wrist Score, and the total active motion and strength levels were compared between patients in whom the plate was removed and those where it was not.

3. Results

The average follow-up was 39 months (± 15.31); there were 10 women and 16 men with an average age of 53 years (± 14.33). The dominant was operated in 13 patients (50%). Thirteen patients (50%) had the plate and screws removed an average of 9 months (± 3.66) later. Two of these patients (15%) had tenosynovitis that was documented with ultrasonography. No tendon ruptures were observed.

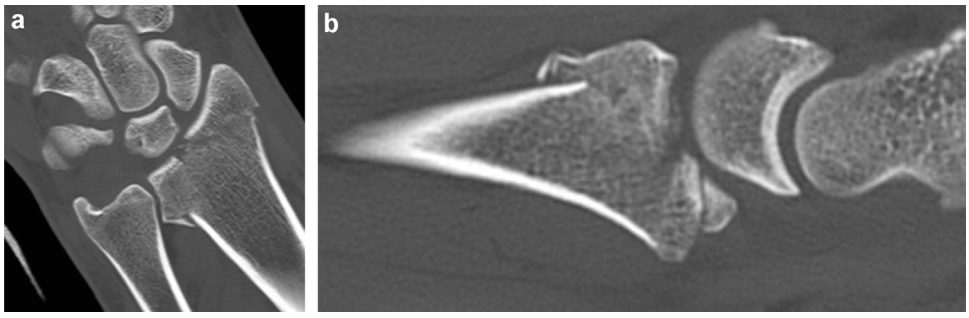

Fig. 2. Preoperative CT scan. Frontal slice showing comminuted joint involvement (a). Sagittal slice through lunate showing comminuted and impacted intra-articular fracture. No damage to the volar metaphysis and epiphysis (b).

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At the time of the review, 18 patients (69%) had returned to their occupation, 3 with restrictions. Five (19%) had not resumed their pre-injury occupation.

3.1. Clinical outcomes

Twenty-two patients (85%) had no pain at rest and eight patients (31%) had no pain during activity. In the 18 patients who had activity-related pain, the VAS ranged from 1 to 4 (out of 10) in 12 of these patients (46%) and 5 or more in the other 6 patients (23%). The QuickDASH was 20 (out of 100) on average (± 10.77). The Mayo Wrist Score was 70 (out of 100) on average (± 18.49). The SANE score was determined in 16 patients; they estimated having 76% (± 18.95) of the overall function of their wrist on average.

The clinical examination found the flexion–extension range of motion to be 92° (± 30.79) on average. Wrist flexion was 37° (± 18.12) and extension was 54° (± 17.34). Pronation was 77° (± 13.73) and supination was 82° (± 11.48) on average. Radial deviation was 15° (± 11.66) and ulnar deviation was 23° (± 8.73). On average, the wrist's range of motion was 82% (± 12.07) of the opposite side. The grip strength of the operated hand was 29 kg (± 12.65) on average and was 36 kg (± 11.38) in the non-operated hand; this meant that the operated hand had regained 81% (± 30.01) of the strength of the control hand. Pinch strength was 7.6 kg (± 2.75) in the operated hand and 8.6 kg (± 2.65) in the non-operated hand; the operated hand could produce 91% (± 27.9) of the pinch strength in the contralateral hand. Table 1 provides a comparison of the outcomes in patients who had the fixation plate removed and those who did not.

3.2. Radiological results

Radial deviation on A/P view was 17° preoperatively (min 5°, max 27°) and 22° postoperatively (min 15°, max 29°). The radial slope on lateral view was −5° (min +16°, max −32°) preoperatively and +6° (min 17°, max −6°) postoperatively (Fig. 3a and b).

The distal radio-ulnar index was −0.16 mm preoperatively (min −4 mm, max +3.5 mm) and 0.97 mm postoperatively (min −1.5 mm, max +3 mm).

Although the angles were measured on standard X-ray views (Fig. 3a and b), it was easier to measure the joint step-off on CT images (Fig. 4a and b). The joint step-off was 2.33 mm on average preoperatively (min 1 mm, max 6 mm) and was corrected to 0.42 mm (min 0, max 1.5 mm) postoperatively (Fig. 5).

In X-rays taken more than 12 months postoperative, signs of post-traumatic osteoarthritis were found in 4 patients (15%). Subchondral sclerosis in the radiocarpal joint, joint space narrowing and osteophytes were the main findings (Fig. 6).

Tenosynovitis of the extensor mechanism was documented on ultrasonography in two patients.

Table 1
Comparison of subjective scores, strength and range of motion for patients who had the plate removed and those who did not. The values given are the mean ± standard deviation.

	Removed (n = 13)	Removed (n = 13)	P value
Mayo Wrist Score	73.08 ± 15.07	67.69 ± 21.66	0.836
QuickDASH	18.85 ± 8.27	21.92 ± 12.97	0.856
Grip strength (% control)	86.54 ± 26.58	76.62 ± 33.42	0.488
Pinch strength (% control)	87.83 ± 24.61	94 ± 31.34	0.763
Range of motion (% control)	81.31 ± 10.63	83.23 ± 13.72	0.644

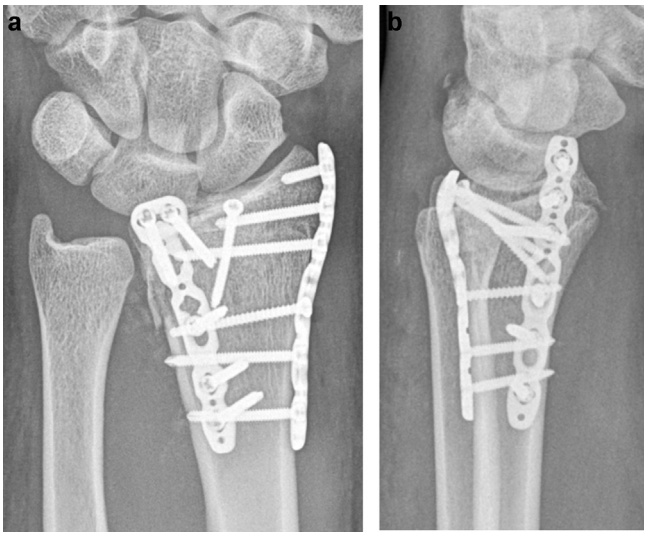

Fig. 3. a: day 2 postoperative X-rays. A/P view: fracture stabilized with two plates and a free screw in the radial and ulnar columns of the distal radius as described by Rickli and Regazzoni [14] (a). Lateral view (b).

4. Discussion

4.1. Dorsal approach

We are satisfied with the subjective and objective results obtained using dorsal ORIF for this type of intra-articular fracture. Nearly 70% of patients were able to return to their

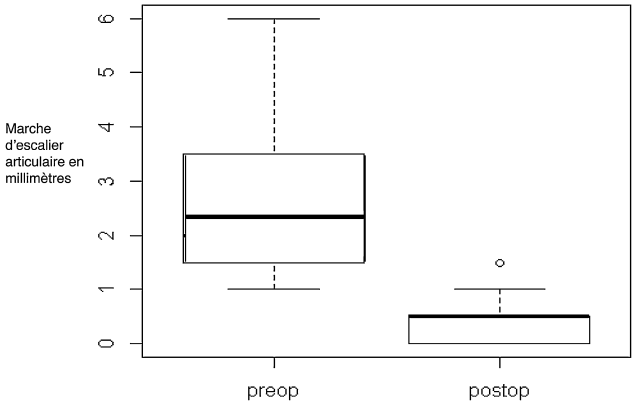

Fig. 4. Comparison between the articular step-off in millimeters between the preoperative and postoperative assessments. This measurement was taken on CT images.

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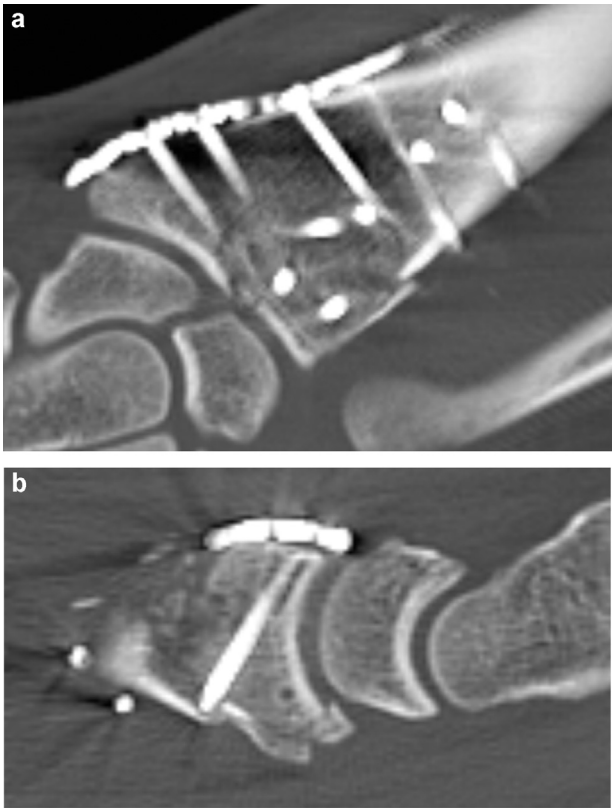

Fig. 5. a: postoperative control CT scan. Coronal slices (a). Reconstruction based on sagittal slices (b). The initial dorsal articular impaction has been corrected.

pre-injury occupation without restrictions, and more than 80% of their grip strength had been restored. The SANE score indicated that patients felt that more than 75% of their overall wrist function had been recovered. Our results are comparable to published results using the same technique [11,13]. Like Fernandez Baca et al. [11], we are convinced that the dorsal approach must remain a treatment option to consider when faced with fractures that affect mainly the dorsal articular portion of the distal radius. We continue to use this technique in 12 to 15 selected cases per year; this allowed us to collect and analyze a sizable number of cases for a technique that is not often described.

Fig. 6. Status 1 year after removal of the plate. A/P and lateral radiographs reveal osteophytes and early joint narrowing.

Even if our study was not comparative, our results are similar to published ones describing other intra-articular visualization techniques (arthroscopy with pinning or volar plate) [9,22].

4.2. Correction of joint congruence

We found radiological signs of early osteoarthritis in 15% of patients. This is consistent with the reported values for this type of fracture due to high-energy trauma that mainly occurs in young patients. No matter which treatment is used, the risk of early osteoarthritis is high, if only due to the associated cartilage damage. This makes it critical to look at the radiocarpal joint and correct any incongruity, along with correcting the alignment in the frontal and sagittal planes [23]. Our data confirms good correction of the joint incongruity, which was reduced from 2.33 mm preoperatively to less than 0.5 mm on average postoperatively.

Statistical analysis revealed that patients with post-traumatic osteoarthritis had a trend toward having higher postoperative articular step-off values than patients without osteoarthritis. This finding is clearly supported by published data [2,23]. However, in our study, this difference was not statistically significant, likely because of the small sample size and low statistical power.

Direct intraoperative visual inspection also ensured that screws do not penetrate the joint. The congruence and absence of intra-articular screws were monitored on the CT images of selected patients. Moreover, direct vision allowed us to place the dorsal plate very close to the joint, while verifying that it would not impair the range of motion of the wrist later on. The average wrist extension value was 54°, no matter if the plate was removed or not.

In the case shown in the figures, dorsal radiotriquetral ligament detachment and VISI carpal misalignment were not treated. These conditions may have an effect on the development of early osteoarthritis, but we did not specifically look at this factor.

4.3. Stable fixation

The other advantages of the dorsal approach are that it is easier to correct the tipping and dorsal comminution [5,10–13,24] and that the stabilization is reinforced by the buttress effect of the radial and ulnar columns of the distal radius [10,14]. The position of the two plates provides stability in two planes: pure dorsal (e.g., posteromedial fragment) and reinforcement by screws from the radial side (Fig. 4a). The plates with locking screws used in this study provide additional stability, especially in osteoporotic bone. We found no signs of secondary displacement of the fixation hardware. In 2008 and 2009, three patients had a loss of joint reduction – despite extended immobilization – that required surgical revision; this

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Table 2
Comparison of various studies publishes since 2005 in which the dorsal approach was used for impacted intra-articular fractures. The fractures were fixed with one or two low profile plates. The rate of plate removal and extensor mechanism tenosynovitis was not given in all the studies.

Study	No. of cases	Follow-up (months)	No. of plates used	Plate removed (cases)	Tenosynovitis	Flexion/extension	Pronation/supination	Strength
Fernandez et al. [11]	12	10	2	–	–	48-0-49°	75-0-80°	75%
Lutsky et al. [13]	15	37	2	–	–	53-0-70°	76-0-80°	87%
Kamath et al. [27]	30	18	1	0	0	81-0-88°	89-0-87°	78%
Simic et al. [28]	51	24	1	1	0	54-0-59°	84-0-78°	90%
Matzon et al. [23]	110	27	1	9	8	67-0-71°	85-0-85°	–
Our study	26	39	2	13	2	37-0-54°	77-0-82°	82%

problem has not reoccurred since then. This complication likely occurred during our learning curve for this technique. The stability of this internal fixation method and the results of our study led us to start the progressive mobilization exercises 2 weeks postoperatively at the latest, in order to avoid stiffness and improve the short-term recovery [25]. In the early part of the study, patients were immobilized in a short volar cast for up to 4 weeks postoperative, as with all other intra-articular fractures treated in our unit at that time.

4.4. Plate-related discomfort

The risk of complications related to the extensor tendons previously described by dorsal fixation [10,26] also exists for volar approaches [27]. This risk is nonetheless clearly reduced by the very low profile titanium plates that are now used [24]. Half of the 26 patients reviewed (in September 2013) after an average follow-up of 39 months needed the plate removed after an average of 9 months because of discomfort. In all cases, the plate was removed fairly soon after the procedure. This leads us to believe that beyond 9 months, the patients no longer have any discomfort due to the plate and do not need it removed. This is confirmed by our post-hoc analysis of patients who did and did not have the plate removed. We found no statistically significant difference in the subjective scores or the strength and motricity between those who did and did not have the plate removed. All patients had very good total range of motion that was at least 80% of the opposite side, whether the plate was removed or not (Table 1). This leaves us with little evidence that patients are better after the plate is removed. However, we were always on the lookout for pain and local swelling associated with crepitation that would make us suspect acute tenosynovitis over the plate; ultrasonography was performed as a consequence. Extensor tenosynovitis was not very common and found in only two patients in our study by ultrasonography. In these two cases, the plate was removed to avoid tendon rupture. These findings are consistent with Matzon's et al. recent study [24], who found an 8% tenosynovitis rate without dorsal plate removal, and other studies [28] [29]. Like in those studies, we did not encounter any tendon ruptures.

4.5. Postoperative stiffness

Patients occasionally complained of reduced wrist flexion, which averaged less than 40°. This range of motion is slightly less than that reported in two other studies [11,13] in which the same surgical technique was used (Table 2). It is likely that the more aggressive postoperative mobilization, implemented partway through our study, will reduce the secondary stiffness of dorsal capsule and ligament structures, and thereby improve wrist flexion.

4.6. Additional assessments

We now perform a CT scan preoperatively, immediately after the surgery and 3 months' postoperative in patients with this type of fracture, after they consent to it. The preoperative CT scan helps with surgical planning [30] and confirms the surgical indication. The immediate postoperative CT scan is used to verify screw positioning and document the correction of the joint congruency [31]. The 3-month postoperative CT scan is used to evaluate bone union in view of removing the plate if necessary. We chose this 3-month time point based on our experience, but a more specific study could be established to determine the best time to perform this scan in the future. There is no consensus in published studies.

4.7. Study limitations

One limitation of the study is the small number of patients included without a control group; however the follow-up did not reveal any tendon damage in the long-term. There is also a possibility that since only half the 47 operated patients were reviewed, the others may have gone to another hospital for their follow-up care. However, our series of patients was homogeneous and our results are consistent with those of other studies describing dorsal fixation of distal radius fractures with low profile plates since 2005. The main results of these studies are summarized in Table 2. Note that some surgical teams used one dorsal plate, while others used two plates as we did.

5. Conclusion

Given our study findings, we are convinced that dorsal ORIF like the one described here has a place in the treatment arsenal for complex intra-articular fractures. We continue to use it for certain impacted fractures that mainly affect the distal radius. The outcomes have improved because of adjustments made during the study (described in the discussion); for example, earlier mobilization was implemented because of the stability

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provided by the buttress effect and the locking screws. The need to remove the dorsal plate, which remains controversial [24,28,29], must still be confirmed, except in cases of clinical and radiological tenosynovitis with risk of tendon rupture. Our results are consistent with those of other surgical techniques used in this type of high-energy fracture.

Disclosure of interest

The authors declare that they have no competing interest.

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