EDITOR'S CHOICE

Radiological, Clinical, and Functional Outcomes of Combined Dorsal and Volar Locking Plate Osteosynthesis for Complex Distal Radius Fractures

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Purpose The purpose of this study was to assess the short- to mid-term radiologic, clinical, and functional outcomes of patients treated with combined dorsal and volar locking plating for internal fixation of complex, comminuted, intra-articular, distal radius fractures.

Methods We performed a retrospective review of 34 patients treated with combined dorsal and volar locking plates for the internal fixation of complex, comminuted, intra-articular distal radius fractures. Radiographic and clinical parameters were recorded at a mean of 48 months after surgery. Activities of daily living and quality of life were assessed by the Disabilities of the Arm, Shoulder, and Hand and Patient-Rated Wrist Evaluation questionnaires.

Results Compared with the contralateral wrist, the treated wrist regained 73% of flexion, 81% of extension, 86% of ulnar deviation, 90% of radial deviation, 98% of pronation, 99% of supination, and 93% of grip strength. Mean Disabilities of the Arm, Shoulder, and Hand and Patient-Rated Wrist Evaluation scores were 11 (range, 0—78) and 11 (range, 0—77), respectively. Radial height and radial inclination were restored anatomically in 24% and 41% of patients, respectively, while volar tilt and ulnar variance were restored in 68% of patients.

Conclusion The overall functional and radiologic outcome of patients with comminuted intra-articular complex distal radius fractures treated with the combined dorsovolar plate osteosynthesis was good to excellent. *(J Hand Surg Am. 2023;48(4):377—387. Copyright © 2023 by the American Society for Surgery of the Hand. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).)*

Type of study/level of evidence Therapeutic IV.

Key words Complex, distal radius fracture, dorsovolar plating, ORIF, outcome.

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COMPLEX INTRA-ARTICULAR distal radius fractures with volar, dorsal, or circumferential comminution are often seen in elderly osteoporotic patients as a result of low energy trauma and as a consequence of high-energy trauma in younger patients.[1,2] The ultimate aim of treatment of distal radius fractures should be a pain-free, mobile wrist without functional limitations.[3] Ng and McQueen[3] stated that a long-term functional outcome following open reduction and internal fixation of a distal radial fracture can be improved by an anatomical reduction, especially in young patients. Reconstruction of the articular surface should be without any major stepoff, and the length of the radius should be restored.[4–11] Insufficient restoration of radial length leads to a relative lengthening of the ulna, which can cause ulnocarpal impaction syndrome.[12–14] Knirk and Jupiter[14] demonstrated that articular stepoff >2 mm results in a higher risk for the development of painful radiocarpal arthrosis. Additionally, persistent dorsal tilt can lead to incongruity in the distal radioulnar joint (DRUJ) and secondary carpal damage caused by the changes in the transfer of forces with dorsal overload and adaptive carpal instability.[8,10,13] In contrast to the treatment aims in young patients, elderly patients might not benefit from complex interventions to attempt to restore anatomy.[15,16]

Over the last 20 years, there has been a clear trend toward volar plate fixation in the management of distal radius fractures, but complex multifragmentary, intra-articular fractures may not be suitable for volar plating only.[17] This may result in an inadequate reduction of central articular fragments, insufficient fixation of dorsoulnar corner fragments, and lack of a dorsal buttress.[18,19] One option for the treatment of this problem is to combine a bridging external fixator with a limited internal fixation or supplementary percutaneous K-wires.[20,21] Major disadvantages of this method are nonanatomic reduction because of insufficient ligamentotaxis and the inability to engage in early mobilization. Arthroscopically-assisted volar plating of these complex fractures is possible and facilitates the anatomic reconstruction of the articular surface. However, arthroscopy remains a challenging procedure in multifragmentary displaced fractures of the dorsal aspect of the radius, exhibiting the same problems for fixation as without arthroscopy.[22,23] Recent reports on the use of a dorsal bridging plate show good results in complex distal radius fractures in patients aged between 55 and 65 years but does not allow for key fragment fixation and early active motion.[24–26]

TABLE 1. Patient Characteristics

Variable	Mean,%	Range, n
Age (y)	57	19–83
Sex		
Male	29	10
Female	71	24
Hand dominance		
Right	85	29
Left	12	4
Both	3	1
Injured hand		
Right	35	12
Left	65	22
Injured hand = dominant hand	38	13
Working patients	44	15
Patients with multiple injuries	65	22

We report the results of a combined volar and dorsal plating of these complex, comminuted, intra-articular distal radius fractures to achieve adequate fracture reduction and fixation. To date, few studies have been reported on the outcomes of combined volar and dorsal locking plating.[1,27–30] However, these studies lacked any long-term follow-up and were limited by small sample sizes. Therefore, our aim was to assess the radiologic, clinical, and functional outcomes of patients who underwent this combined fixation technique.

METHODS

After institutional review board approval, a search of the electronic medical records database found that between August 2009 and June 2016, 59 patients of a total of 806 with nonoperatively- and operatively-treated distal radius fractures underwent a combined dorsal and volar locking plating surgery for intra-articular, complex, distal radius fractures at the Department of Hand Surgery at our hospital.

Patients were eligible for inclusion if they met all the following criteria: surgical treatment with a combined dorsal and volar plate osteosynthesis, were at least 18 years of age on the date of surgery, and consented to study participation. Of the 59 patients initially identified, 34 (58%) were included and informed consent in compliance with Health Insurance Portability and Accountability Act was obtained. Sixteen (27%) patients were excluded owing

FIGURE 1: Pre- and postoperative radiographs in a patient with complex distal radius fracture using combined dorsal and volar plating.

to refusal of study participation, 4 (7%) were unavailable for follow-up, and 5 (8%) were deceased.

Patient characteristics

The mean age of the included patients was 57 years (range, 19−83 years). Of the 24 (71%) women and 10 (29%) men included, 29 were right-handed, 4 were left-handed, and 1 was ambidextrous. The dominant hand was injured in 13 (38%) patients. Detailed patient characteristics are summarized in Table 1.

Surgical technique

In all patients, a modified Henry approach and a dorsal approach through the third extensor compartment using an extensor retinaculum flap described by Lutsky et al[31] and Devaux et al[32] was performed. Neurotomy of the posterior interosseous nerve at the floor of the fourth extensor compartment and subcutaneous transposition of the extensor pollicis longus tendon was performed in all cases. Titanium locking plates (Medartis AG and Depuy Synthes; Fig. 1) were used for volar and dorsal fixation. The fracture, and especially the volar ulnar fragment, was stabilized using a volar plate and, if necessary, a plate-dependent screw or K-wire. The dorsoulnar fragment and the radial fragment were then repositioned, and preliminary fixation was achieved using K-wires. The reduction was checked directly through the arthrotomy. In cases of large defect zones, the fragments were supported using a cancellous allogenic bone graft. A Pi-shaped dorsal plate then was fixed temporarily in the oblique plate holes, and locking-head screws were subsequently placed in the distal plate row. Intraoperative fluoroscopy was used to check the reduction, position of the plates, and ulnar variance. If needed, plates and the reconstructed articular fragments could be moved in the oblique plate holes to gain length. Throughout the 7-year study period, 12 experienced hand surgeons (level IV−V) performed all surgical procedures.[33]

Postoperative management

After surgery, patients were referred to a certified hand therapist and were guided and instructed throughout the whole postoperative course of therapy. The wrist was placed in a custom-made thermoplastic dorsovolar splint for 4 weeks (Fig. 2) followed by another 4 weeks in a prefabricated wrist brace. Active finger exercises were allowed immediately, and active wrist exercises were started 2 weeks after the surgery. Strengthening and weight-bearing exercises were started 8 weeks after the surgery.

Data collection

Patient-specific, surgery-specific, and clinical data, including postoperative complications, were retrospectively collected and recorded based on medical reports and surgical documentation. Clinical and

FIGURE 2: Custom-made thermoplastic dorsovolar splint.

radiologic follow-up was usually performed at 4, 8, and 16 weeks after surgery, as well as before and after implant removal, with documentation of the active range of motion and grip strength (Jamar dynamometer). In addition to the retrospective data analysis, all the study participants were followed up again between May and June 2017, an average of 48 months after surgery (range, 12–92 months).

Activities of daily living and quality of life were assessed using the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire and the Patient-Rated Wrist Evaluation (PRWE) Score at the last follow-up.[34,35]

Fracture assessment was performed using the Patient, Accident and Fracture documentation by Herzberg et al.[36] Plain radiographs and, if available, computed tomography (CT) scans of the wrist at specific time points (injury, 4, 8, and 16 weeks after surgery, before and after implant removal and last follow-up in May or June 2017) were analyzed retrospectively by 3 independent observers (1 senior consultant of hand surgery, 1 consultant, and 1 resident with 2 years of experience in hand surgery) using the digital radiologic viewing software IntelliSpace PACS Enterprise (Philips). To assess the complex fracture characteristics in detail and guide a suitable treatment strategy, we used, in most cases, preoperative multislice CT or cone-beam CT. Cone-beam CT has good sensitivity, fast availability, low radiation dose, and lower costs.[37,38] Fractures were classified according to the revised AO classification system and the Fernandez classification.[39,40]

After identification of the key articular fragments and fracture pattern, the decision for the surgical approach was taken. The aim was to sufficiently stabilize the intra-articular key fragments and the metaphyseal distal radius to provide sufficient primary stability. These goals are supported by the 4-corner concept of Brink and Rikli[19] as well as the CT-based assessment and clinical decision-making of Hintringer et al.[18]

Methods for measurements were based on those described by Mann et al.[41] In the posterior-anterior view, the radial inclination, radial height, and ulnar variance were measured. In the lateral view, the palmar or dorsal tilt and any anterior or posterior translation of the distal radius with respect to the diaphysis were measured. In addition, anterior, posterior, or circumferential comminution as well as articular sagittal widening was recorded. Radiocarpal stepoffs and gaps were documented based on the evaluation of standard radiographs, and if available, on preoperative and follow-up CT scans. A CT scan was performed in 27 patients preoperatively for fracture assessment, in 5 patients 4 weeks after surgery, in 22 patients before implant removal to check for bony healing, in 5 patients after implant removal, and in 1 patient at the last follow-up. Transverse CT scan slices were used to define stepoffs or gaps in the sigmoid notch and also to identify the number of major fragments according to Medoff's classification.[42] The presence of complete destruction of the distal radial surface, localized impaction, associated DRUJ lesions, carpal injuries, any volar or dorsal radiocarpal subluxation, accompanying fractures of the ulna (neck, head, or ulnar styloid), and DRUJ incongruence, were recorded.

Standardized acceptable values for each measurement were based on the published literature as a volar tilt of 11° (SD, 5°), radial inclination of 22°(SD, 3°), radial height of 14 mm (SD, 1 mm), ulnar variance of 0.7 mm (SD, 1.5 mm), stepoff of <2 mm, and gap of <2 mm.[4,5,14,42–45]

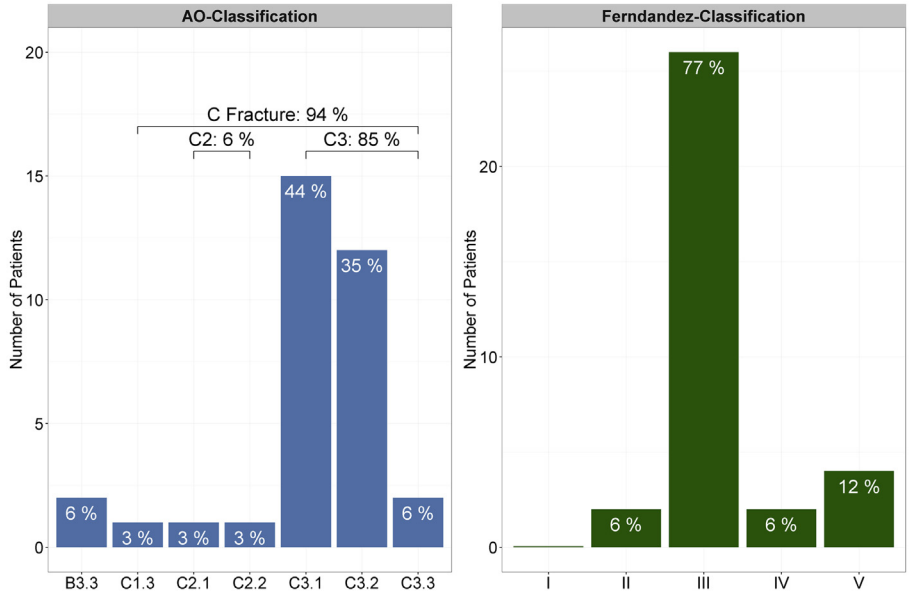

FIGURE 3: Fracture classifications.

Statistical analysis

For radiographic measurements, the mean values of all 3 observers were obtained and used for further statistical analysis. The sample was summarized by demographic variables in which the minimum, maximum, and mean are given for continuous variables (eg, age, DASH and PRWE scores, grip strength, range of motion, radiographic parameters). Proportions were given for categorical variables (eg, sex, hand dominance, complications). The proportion of patients within the normal ranges of radiologic measurements was given for each time point and fracture type. Furthermore, the mean, SD, minimum, and maximum of each measure were given by time point and fracture type.

RESULTS

The median of clinical and radiologic postoperative follow-up was 48 months (range, 12–92 months). In 88% (n = 30) of patients, a preoperative X-ray and in 79% (n = 27) of patients, a preoperative CT scan was performed. Of the 32 (94%) patients with implant removal, all patients received an X-ray and 22 (65%) patients received an additional CT scan before implant removal. After implant removal, an X-ray was performed in 29 (85%) patients and a CT scan in 5 patients. For 4 patients, no radiographic data were available for this time point. In all 34 study participants, X-rays were taken at the last follow-up and 1 patient received an additional CT scan.

TABLE 2. Fracture Fragments According to Medoff's Classification

Fragment number	%	n
5	19	5
4	52	14
3	22	6
2	7	2
1	0	0

Data presents distribution of number of major fracture fragments according Medoff's classification using CT scan slices for evaluation (n = 27).[42]

Fracture characteristics

Fracture distribution according to the AO- and Fernandez classification and fracture-specific data including fracture fragments according to Medoff's classification are shown in Figure 3 and Table 2. In 71% (n = 24) of patients, there was an impaction and in 9% (n = 3) the articular surface was considered nonrepairable. A total of 74% (n = 25) of fractures presented with sagittal articular widening. The fracture was distal to the watershed line in 53% (n = 18) of patients. Circumferential comminution was seen in 41% (n = 14), dorsal comminution was seen in 38% (n = 13), and palmar comminution was seen in 21% (n = 7) of patients. Dorsal or palmar radiocarpal subluxation was documented in 27% (n = 9) and 15% (n = 5) of patients, respectively. In 38% (n = 13), there was DRUJ incongruency. Dorsal or palmar

TABLE 3. Radiographic Outcome

Time of measurement	X-ray, n	Months after surgery	Volar tilt	Radial inclination	Ulnar variance	Radial height	Radiocarpal stepoff x-ray	Radiocarpal gap x-ray	CT, n	Radiocarpal stepoff CT	Radiocarpal gap CT	Sigmoid notch stepoff CT
Injury												
Overall %	30	–	24% (7/29)	17% (5/30)	17% (5/29)	7% (2/30)	70% (21/30)	38% (11/29)	27	41% (11/27)	7% (2/27)	82% (22/27)
Mean (SD)			−7° (22.2°)	14° (9.1°)	4 mm (2.6 mm)	8 mm (5.5 mm)	2 mm (1.8 mm)	3 mm (3.0 mm)		3 mm (1.5 mm)	5 mm (2.7 mm)	1 mm (1.1 mm)
Range			−48–30°	−13–27°	−2–11 mm	−7–18 mm	0–9 mm	0–13 mm		0–8 mm	2–10 mm	0–3 mm
After implant removal												
Overall %	29	84–29	64% (18/28)	41% (12/29)	59% (17/29)	28% (8/29)	86% (25/29)	79% (23/29)	5	40% (2/5)	20% (1/5)	100% (5/5)
Mean (SD)			12° (7.4°)	25° (3.6°)	1 mm (1.7 mm)	13 mm (2.1 mm)	1 mm (1.2 mm)	1 mm (1.4 mm)		3 mm (1.4 mm)	5 mm (2.6 mm)	1 mm (0.8 mm)
Range			−9–25°	15–31°	−3–4 mm	8–19 mm	0–6 mm	0–5 mm		2–5 mm	2–8 mm	0–2 mm
Last follow-up												
Overall %	34	4812–92	68% (23/34)	41% (14/34)	68% (23/34)	24% (8/34)	97% (32/33)	91% (30/33)	1	100% (1/1)	0% (0/1)	100% (1/1)
Mean (SD)			11° (7.6°)	25° (3.9°)	1 mm (1.6 mm)	13 mm (2.0 mm)	0.5 mm (1.1 mm)	0,5 mm (1.1 mm)		1 mm (–)	6 mm (–)	0 mm (–)
Range			−12–31°	18–33°	−2–4 mm	10–19 mm	0–6 mm	0–5 mm		–	–	–

Data represents the percentage of fractures that fall into the normal range for each parameter, the mean and standard deviation and the range of measurements of each parameter. Negative values indicate dorsal tilt or negative ulnar variance, respectively.

TABLE 4. Subjective Functional Outcomes

Scores	N	mean (range)
DASH score		
Work	18	11 (0–88)
Music and sport	20	10 (0–56)
Total	34	11 (0–78)
PRWE score		
Pain	34	7 (0–34)
Functional	34	5 (0–45)
Total	34	11 (0–77)

Subjective functional outcomes at the last follow-up, mean 48 months after surgery.

TABLE 5. Objective Functional Outcomes

Functional scores	mean (range)	% of healthy side
Grip strength (kg)	28 (4–54)	93
Range of motion		
Flexion (°)	49 (20–70)	73
Dorsal extension (°)	52 (20–70)	81
Ulnar deviation (°)	32 (15–50)	86
Radial deviation (°)	18 (0–25)	90
Pronation (°)	83 (60–90)	98
Supination (°)	82 (60–90)	99

Functional outcomes at the last follow-up, mean 48 months after surgery.

sagittal translation was documented in 62% (n = 21) and 44% (n = 15) of fractures, respectively. A total of 56% (n = 19) of patients had an additional ulnar styloid fracture and 9% (n = 3) had an ulnar head fracture.

Surgery characteristics

A temporary external fixator was used in 18% (n = 6) of patients before definitive internal fixation. Two patients included in the study had a loss of reduction after initial isolated dorsal plating of a complex distal radius fracture. In 68% (n = 23) of patients, cancellous bone allograft was used for the augmentation of defect zones. A simultaneous carpal tunnel release was performed in 24% (n = 8) of patients due to acute posttraumatic carpal tunnel syndrome (n = 6) and for prophylactic reasons (n = 2). Only 1 of the 19 ulnar styloid fractures required screw fixation. Complete implant removal was performed in 94% (n = 32) cases at an average of 7 months after surgery (range, 4–16 months).

Radiologic outcome

The mean volar tilt was corrected from −7° to 11° and the mean radial inclination improved from 14° to 25°. Mean ulnar variance was reduced from 4 mm to 1 mm and the mean radial height improved from 8 mm to 13 mm. Further radiologic outcomes are summarized in Table 3.

Clinical outcome

The subjective and objective functional outcomes at the last follow-up are summarized in Tables 4 and 5. Of note, the most impaired parameter was flexion, which was a mean of 73% of the contralateral side. Compared to the healthy side, >80% was attained for mean dorsal extension and ulnar deviation and >90% for pronation, supination, radial deviation, and grip strength, respectively.

Adverse events

Eighteen adverse events were recorded in 16 patients (47%; Table 6), including 3 cases of loss of reduction, 1 after implant removal due to insufficient union, which required a repeat fixation with a palmar plate and iliac crest bone graft. The other 2 patients did not require any operative intervention and were free of pain. Because of persisting pain and stepoff in the articular surface, 3 patients needed a corrective osteotomy of the distal radius from which 1 patient still has persisting pain, but no limitations in daily activities and did not want further interventions. A symptomatic nonunion of the ulnar styloid and posttraumatic ulnar impaction syndrome occurred in 1 patient, which was treated with resection of the ulnar styloid and a wafer procedure. One patient had postoperative palmar intercalated segmental instability with intact lunotriquetral ligaments caused by an insufficient suture of the dorsal joint capsule, which was corrected during implant removal. Two patients were treated with antibiotics due to a superficial wound infection not requiring surgical intervention. Three patients showed early signs of a complex regional pain syndrome type I, and were treated with Vitamin C, calcitonin, and dimethyl sulfoxide cream, which was associated with complete remission of the symptoms.

DISCUSSION

Dorsovolar plating is a treatment option for highly comminuted, complex, intra-articular fractures offering the potential advantage of anatomic

TABLE 6. Adverse Events

Adverse events	%	n	Treatment
Patients with adverse events	47	16	
Number of adverse events		18	
Mild	11	2	
Loss of reduction	6	2	No revision needed
Moderate	61	11	
Scar problems (ie, traumatic neuroma)	9	3	Scar revision
CRPS	9	3	Vitamin C, calcitonin, dimethyl sulfoxide
Wound infection	6	2	Antibiotics
Intra-articular screw	3	1	Early screw removal
Tendon rupture EIP and partially EDC II	3	1	Stabilizing core suture of the EDC II tendon
PISI position	3	1	Suture of the dorsal joint capsule
Severe	28	5	
Incongruence of articular surface	9	3	Corrective osteotomy
Loss of reduction caused by non/insufficient union	3	1	Repeated fixation with a palmar plate and iliac crest bone graft
Nonunion ulnar styloid and ulnar impaction syndrome	3	1	Resection of the ulnar styloid and wafer procedure

Adverse events according to the grading used by the Food and Drug Administration.[53] CRPS, chronic regional pain syndrome; EDC, extensor digitorum communis; EIP, extensor indicis proprius, PISI, palmar intercalated segmental instability.

reduction and fixation and early mobilization, which is not possible when using an external fixator or bridging plate. Little is known about the short- to mid-term clinical and radiologic outcomes of this technique.

The results of combined dorsal and volar plating with nonlocking systems reported by Fitoussi et al[46] and Beyermann and Prommersberger[27] showed good anatomic restoration, but a reduction of range of motion and strength of approximately 25% to 30% of the healthy side. Beyermann and Prommersberger,[27] in their series of 1 AO type A3, 6 type C2, and 9 type C3 fractures, mentioned that palmar tilt was difficult to restore, but that articular steps >2 mm could be avoided. At an average follow-up of 34.5 months, none of the 16 patients exhibited notable degenerative changes compared with 5 of 12 in the series of Fitoussi et al.[46] However, 4 of the 5 patients showed intra-articular stepoff of >2 mm immediately after surgery, highlighting the importance of addressing a step deformity in the articular reconstruction.

A study by Ring et al[29] using dorsovolar locking plates in 25 patients with AO type C3.2 fractures confirmed good radiologic restoration and clinical outcome after a mean follow-up of 26 months. Grip strength averaged 78% of the uninjured hand, and they reported extension 54°, flexion 51°, pronation 79°, and supination 74°. Of note, in an undefined number in this series, an external fixator was used intraoperatively to facilitate reduction and was left after surgery for 4 weeks to protect the osteosynthesis. In our opinion, this is now rarely necessary with fragment-specific plates and locking-head screws.

Day et al[1] reported on the results of "sandwich plating" in 10 patients with AO type C2 (n = 3) and type C3 (n = 7) fractures with a mean follow-up of 17 months. Nonlocking, low profile, stainless steel plates were used on the dorsal side in all cases and on the volar side in 7 cases, whereas in 3 cases locking volar plates were used. None of the plates were removed, and no tendon ruptures occurred.

Sagerfors et al[47] reported the largest short-term series using dorsal and volar locking plates in 80 patients with AO type C2/C3 fractures. The investigators reported on comparable values of the range of motion and grip strength compared to the uninjured side of 75% and 70% of flexion, 73% and 74% of extension, 88% and 90% of supination, 95% and 94% of pronation, and 72% and 80% of grip strength.[1,47] In all 3 of these studies, palmar tilt was difficult to restore.

With a range of motion between 73% flexion and 99% supination and grip strength of 93% of the uninjured side, our clinical findings are comparable to

those in the literature on isolated dorsal or palmar plating and on combined dorsal and volar plating.[1,28–30,47–50] The median DASH and PRWE scores of our patients compare better to those reported by other studies using combined or isolated palmar plating.[1,28,47,50,51] The radiologic findings were comparable to prior studies on dorsovolar fixation, except for better restoration of palmar tilt of 11° (mean) in our series. This might be attributable to the use of dorsal and volar locking plates in our series compared to nonlocking systems in earlier series.

The high rate of implant removal in our group was not related to complications. It has been a policy to remove all implants after secured fracture healing. This policy was based on the fact that older dorsal implants tended to be bulky and disturbing, and that no long-term data with this new anatomically shaped dorsal plate were available.

Seven percent of all our surgically treated patients with distal radius fractures needed dorsovolar plating. Of this 7%, 85% were AO C3 fractures, and 70% showed 4 or 5 fragments according to Medoff's classification. In 89% impaction occurred with considerable gaps and defect zones, which explains the frequent use of cancellous allogeneic bone augmentation in more than two-thirds of our cases. In contrast to published results, only in a few cases (18 %) was a temporary external fixator required and the osteosynthesis performed later.[52]

A high rate of adverse events was observed in our series (47% of all patients). We categorized adverse events as mild (11%), moderate (61%), and severe (28%), as listed in Table 6. In general, the complication rates are difficult to compare because of the nonstandardized reporting among the studies. That is why we used a grading that is used by the Food and Drug Administration.[53,54]

In a recent study, AO type C fractures were associated with an increased complication rate.[55] Extensor tendon rupture is a known problem of dorsal plating with reported tendon complication rates up to 32%.[56–59] In our study, only 1 patient (3%) incurred an extensor tendon rupture, which may be due to the fact that it has been a policy at our center to remove implants after bony union. Sanchez et al[60] reported a similar policy with a removal rate of 76%.

Despite a combined dorsal and volar approach with a large amount of hardware, devascularization and osteonecrosis do not appear to be important considerations and most of the fractures healed. We observed one case of non/insufficient union, with a loss of reduction after implant removal, which required further surgery. It could have been avoided if a metal-reduction protocol (eg, dual-energy) CT would have been used to judge healing before the removal of the implant.

The results should be interpreted and judged in the context of the limitations of our study. At the time of the study, the radiographs of the wrist were not standardized and could potentially lead to differences in angulation and rotation of the X-rays. The definition of the dorsovolar plate fixation as inclusion criteria led to a heterogeneous patient group with different fracture types, which might have led to a selection bias. The retrospective design, rate of follow-up of only 60%, and lack of a control group are also limitations. Therefore, our results are applicable only for a small but important group of patients who have sustained complex comminuted intra-articular distal radius fractures. Treatment options for these kinds of fractures remain in discussion due to the heterogeneity of fracture patterns and patients, surgical experience, and availability of studies with a higher level of evidence.

For our patient group, we can confirm the good to excellent overall functional and radiologic outcome after dorsovolar plate fixation of complex distal radius fractures reported in earlier studies.

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