Combined Plating of Intra-Articular Distal Radius Fractures, a Consecutive Series of 74 Cases

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Abstract

Background The distal radius fracture (DRF) is the most common fracture in adults. For unstable intra-articular fractures, the choice of treatment is often operative. The optimal choice of fixation remains a matter of discussion.

Question/Purpose Can combined volar and dorsal plating, using a dorsal frame plate, achieve a good functional and radiographic 1-year outcome in intra-articular DRFs?

Methods In a retrospective cohort study, we evaluated 74 consecutive patients operated with combined plating using a volar plate and a dorsal frame plate. The DRFs were operated between 2016 and 2017 and all cases were AO type C intra-articular fractures. The primary outcome was patient-reported outcome measures including radiographic examination 1 year postoperatively. Secondary outcome measures included wrist range of motion, visual analog scale (VAS) pain scores, and hand grip strength.

Results The median patient-rated wrist evaluation score was 18 points; the quick disabilities of the arm, shoulder, and hand score was 14.8 points. The median Batra radiographic score was 88. Wrist extension was 76% of the uninjured side, flexion was 74%, pronation was 94%, and supination was 94%. VAS pain scores were 0 at rest and 2 during activity. Hand grip strength was 82% compared with the uninjured side. The radiographic outcome according to Batra did not correspond to the patient-reported outcome. Patients older than 60 years had significantly better QuickDASH (quick disabilities of the arm, shoulder, and hand) and PRWE scores (patient-rated wrist evaluation scores) and less pain during activity compared with younger patients despite similar radiographic outcome. There were no tendon ruptures; hardware removal was performed in 21 of the 74 patients.

Conclusion The radiographic outcome did not correspond to the functional outcome 1 year postoperatively. Older patients report less pain and better functional outcome compared with younger patients. There were no tendon ruptures and the frequency of hardware removal was acceptable. Complex intra-articular DRFs AO type C can be managed with volar and dorsal frame-plate fixation to restore distal radius anatomy and achieve a good functional outcome.

Keywords

- distal radius fracture
- plating
- range of motion
- visual analog scale

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The distal radius fracture (DRF) is the most common fracture among adults, representing 18% of all fractures in an orthopaedic trauma unit.¹ The annual incidence in Sweden is estimated to be 26 per 10,000 inhabitants.² Nonoperative treatment is usually chosen for nondisplaced and displaced but reducible fractures.³ Displaced and unstable fractures which cannot be reduced are often considered for operative treatment.⁴ The treatment of DRF has shifted in recent years and there has been a trend toward more surgery.⁵ Volar locking plates have gradually replaced previously common interventions like pinning, nonlocking plates, or external fixation.⁶ The degree of evidence supporting this shift is low.⁷ One study indicates that the shift in surgical treatment in recent years has had no influence on the subjective outcome for the patients.⁸ The optimal type of operation and choice of implant remain a matter of discussion. Some studies have indicated that volar locking plates have better patient-reported outcome and better range of motion (ROM) compared with older techniques.^{9–11} Other studies indicate that volar locking plates and external fixation can yield similar results.¹² Good results have been reported for combined volar and dorsal plate fixation of complex intra-articular DRFs using the pi-plate system; however, this implant has been discontinued by the manufacturer.^{13–15} Reports on combined volar and dorsal plating of complex intra-articular fractures using modern implants are scarce. In addition, some studies indicate that for older patients with a DRF, the functional outcome is the similar regardless type of treatment.^{16,17}

The aim of the present study was to assess the outcome after combined volar and dorsal plating, in a consecutive series of 74 patients with an intra-articular DRF, using a dorsal frame plate with 1-year follow-up, all operated at a Swedish tertiary referral center (► Fig. 1).

Materials and Methods

This retrospective study was approved by the Swedish Ethical Review Authority reference number 2019-00089. All patients undergoing surgery for DRFs at the Department of Hand Surgery, University Hospital in Örebro, Sweden, between November 1, 2016 and May 31, 2017 were identified. Inclusion criteria for the study were; AO (Arbeitsgemeinschaft für Osteosynthesefragen) type C fractures that were treated with a combined volar plate and dorsal frame plate (Dorsal Frame Plate 2.5, Medartis AG, Basel, Switzerland).¹⁸ Exclusion criteria included; patients under the age of 18 years, difficulty to understand Swedish, dementia, mental illness, alcohol/substance abuse, and metabolic bone disease. A total number of 127 patients were treated operatively at our institution during the period of the study. Of these 127 patients, 78 met the inclusion criteria for the study (► Fig. 2).

Surgical Technique

All fractures in this study were treated with combined volar and dorsal plate fixation using the Medartis Dorsal Frame Plate system. To visualize the volar ulnar part of the distal radius, a central incision including a carpal tunnel release was used. The fracture was exposed in the interval between the finger flexors and the median nerve where the median nerve is retracted

radially with the flexor carpi radialis and the flexor pollicis longus tendons. After division of the pronator quadratus muscle, the fracture fragments were reduced and a volar plate was applied to the volar surface of the distal radius using locking unicortical screws distally. A dorsal exposure through a longitudinal incision was centered over Lister's tubercle/the third metacarpal. The fourth extensor compartment was opened in a Z-shaped manner and the fracture was exposed using careful subperiosteal dissection. The radial extensors were retracted radially and the brachioradialis insertion was released to reduce the pulling forces on the distal fracture fragments. Impacted articular fragments were reduced and stabilized with locking screws distally. This completes a cage of volar and dorsal locking screws supporting the articular fragments, an important feature in cases with severe comminution and metaphyseal defects. Bone graft or bone graft substitutes were not used. In cases with a concomitant ulnar styloid fracture and distal radioulnar joint instability (assessed intra-operatively after placement of the volar and dorsal plates), the ulnar styloid was stabilized using a 2.0-mm locking distal ulna plate (DePuy Synthes, Westchester, PA). In case of a concomitant scapholunate dissociation, the ligament was sutured with 2.0 Ethibond (Ethicon, Somerville, NJ) osteosutures and the scapholunate articulation pinned using 1.2-mm K-wires after reduction of the carpal bones using K-wires as joysticks. A splint was used for the first 2 weeks postoperatively. Thereafter, gentle mobilization of the wrist with a removable splint was initiated under the guidance of a hand therapist. In case of an ulnar styloid fracture that was stabilized operatively, an above-the-elbow cast was used for 4 weeks; in case of a scapholunate ligament suture, an above-the-elbow cast was used for 6 weeks. All patients were seen by an experienced hand therapist and given instructions on exercises to reduce edema before being discharged from the hospital on the day following surgery. The patients were allowed to use the wrist without a splint with the exception of lifting heavy objects, this was discouraged for the first 3 months postoperatively for patients with isolated DRFs.

Clinical Evaluation

The following outcome measures were administered prospectively by the department's hand therapists in both the operated and the uninjured wrist 1 year postoperatively as part of the department's clinical routine: pain (VAS at rest, VAS during activity), hand grip strength (kg), pinch grip (kg), key pinch grip (kg), wrist ROM (flexion, extension, radial deviation, ulnar deviation, pronation, supination), patient-rated wrist evaluation (PRWE-score), and quick disabilities of the arm, shoulder, and hand (QuickDASH) score.

The patients rated wrist pain according to the visual analog scale (VAS) both at rest and during activity where 0 = no pain and 10 = worst imaginable pain. Hand grip strength measurements were done by an experienced physiotherapist using a hydraulic Jamar hand dynamometer (North Coast Medical Inc., CA). For key pinch and pinch grip strength measurements, a pinch gauge was used (North Coast Medical Inc., CA). ROM for wrist flexion, extension, radial deviation, ulnar deviation, pronation, and supination was registered by a physiotherapist

using a goniometer. Measurements were done according to the Swedish National Manual for measuring motion and strength in the elbow, forearm, and hand.¹⁹

The patients completed the Swedish validated translations of the questionnaires PRWE and QuickDASH.^{20,21} The PRWE consists of a 15-item questionnaire and is validated to measure wrist pain and disabilities in daily living. A score of 100 is calculated where 0 represents no pain or disability. The QuickDASH is a region-specific outcome instrument for the upper extremity that measures disabilities and symptoms. The Quick-DASH score has an 11-item disability scale regarding the patient's health during the preceding week. A score is calculated from 0 to 100 where 100 represents the

most severe disability. Causes for secondary surgery were noted and analyzed.

Radiographic Assessment

Radiographic examination of the wrist was done preoperatively, immediately postoperatively, and 1 year postoperatively. Anteroposterior and lateral views were taken. Assessment of the DRFs according to the AO classification was done by the operating surgeon using preoperative radiographs and intraoperative findings.¹⁸ Radiographic findings 1 year postoperatively were assessed according to the Batra anatomical scoring system.²² The Batra anatomical score includes assessment of five components; the radial

Fig. 1 (A, B) Intra-articular DRF preoperatively. DRF, distal radius fracture.

Fig. 2 (A, B) Intraoperative radiographs.

angle, radial length, volar tilt, articular incongruity, and the radioulnar joint. A summarized score is calculated assessing the skeletal anatomy where the maximum result is 100. The Batra anatomical score is divided into four groups: excellent (100–90), good (89–80), fair (79–70), and poor (<70). Assessment of the Batra anatomical score was done by a consultant hand surgeon at our institution.

Statistics

Data are presented as median and interquartile range due to a non-normal distribution. The normal distribution was assessed using Shapiro–Wilks test (data not shown). A Wilcoxon rank sum test was used to assess the outcome between

the injured and uninjured side. To assess differences between the four groups of radiographic Batra-score regarding PRWE-score, QuickDASH-score, VAS-score during activity, and summarized wrist flexion/extension, a Kruskal–Wallis test with Bonferroni-corrected post-hoc tests was used. It was also used to assess the differences between AO fracture-types C1, C2, and C3 regarding VAS-score during activity, PRWE-score, QuickDASH-score, and summarized wrist flexion/extension. To assess differences between older and younger patients, the cohort was dichotomized in two groups; patients ≤ 60 years and patients ≥ 61 years. The two age groups were compared using Mann–Whitney U-test. A corrected $p < 0.05$ was considered to be statistically significant.

Fig. 3 (A, B) Radiographs 1 year postoperatively.

Results

Of the 78 patients, three patients with bilateral fractures were excluded, one patient died of unrelated causes before the 1-year follow-up. Thus, 74 patients completed the 1-year follow-up examination. In three cases with a comminuted fracture extending proximally on the volar side, the volar Medartis 2.5 TriLock Distal Radius Frame Plate was found to be too short and instead, a DePuy Synthes (Westchester, PA) volar locking plate (2.4-mm variable angle LCP [locking compression plate]) was used in combination with the Medartis dorsal frame plate. These three cases were included in the 1-year follow-up. The ulnar styloid was stabilized operatively in one patient. One scapholunate ligament injury was sutured. Demographic characteristics regarding age, sex, injured side, and fracture type according to the AO-classification are found in ► **Table 1**. Mean pronation and supination was 94% of the uninjured side, dorsal wrist extension was 76% of the uninjured side, and wrist flexion was 74% of the uninjured side. The grip strength was 82% of the uninjured side. The VAS pain score at rest was 0, the VAS pain score during activity was 2. The median PRWE score was 18 and the Quick-DASH score was 14.8 (► **Table 2**). Hardware removal during the first year postoperatively was undertaken in 21 of 74 patients (28%); the reason for hardware removal was dorsoradial wrist pain/extensor tenosynovitis around the second dorsal tendon compartment. Two cases had a postoperative infection, which healed with antibiotics treat-

ment. There were no cases of tendon rupture or complex regional pain syndrome (CRPS) during the 1-year follow-up period. The median Batra score was 88, the radial angle was 21 degrees, and the volar tilt 2.5 degrees (► **Table 3**). Fifty-five out of the 74 cases had a good to excellent Batra score (► **Table 4**). Both age groups had a median Batra radiographic score of 88. The older patient group had a significantly lower PRWE-score of 10.5 compared with 27.8 for the younger patients and a significantly lower QuickDASH-score of 9.1 compared with 22.7 for the younger patients (► **Table 5**). VAS pain scores were also significantly lower for the older group.

There was no statistically significant difference between the three groups of AO fracture types (C1, C2, and C3) and the 1-year outcome regarding PRWE-score, QuickDASH-score, summarized flexion/extension, and VAS during activity. In addition, there was no statistically significant difference between the four groups of radiographic Batra score (► **Table 4**) and the 1-year outcome regarding PRWE, QuickDASH, summarized flexion/extension, and VAS during activity. Three patients did not undergo a radiograph at the 1-year follow-up. For these three patients, the Batra-score was calculated using the radiographs from the 3-month follow-up.

Discussion

The findings from this study indicate that combined plating can yield a good functional and radiographic short-term outcome in patients with AO type C intra-articular DRFs.

Combined plating using the pi-plate has previously demonstrated a good outcome in the treatment of complex DRFs.^{14,15,23,24} However, the pi-plate has been discontinued by the manufacturer. The dorsal frame plate is a modern plate with a smooth low-profile surface sharing some similarities

Table 1 Demographic data

Male/female	Median age (range)	Side fractured Right/left	AO type C1/C2/C3
19/55	62 (21–79)	33/41	8/41/25

Table 2 Wrist function 1 year postoperatively

Outcome measure	Injured side	Mean percentage of uninjured side	Uninjured side	p-Value
Pronation (degree)	75 (70, 80)	94	80 (75, 85)	<0.0001
Supination (degree)	80 (70, 85)	94	85 (75, 90)	<0.0001
Volar flexion (degree)	60 (50, 65)	74	75 (70, 80)	<0.0001
Dorsal extension (degree)	50 (45, 60)	76	70 (64, 75)	<0.0001
Radial deviation (degree)	20 (15, 25)	85	25 (20, 25)	<0.0001
Ulnar deviation (degree)	25 (25, 30)	80	35 (30, 40)	<0.0001
Grip strength (kg)	26 (21, 32)	82	32 (26, 38)	<0.0001
Pinch grip (kg)	4.5 (4, 6)	89	5.3 (4.5, 6.5)	<0.0001
Key pinch grip (kg)	7.0 (5.9, 8.5)	92	7.8 (6.5, 9.0)	<0.0001
VAS at rest (mm)	0 (0, 0.3)			
VAS during activity (mm)	2 (1, 4)			
PRWE score (points)	18 (7, 32)			
QuickDASH score (points)	14.8 (4.5, 29.5)			

Abbreviations: PRWE, patient-rated wrist evaluation; QuickDASH, quick disabilities of the arm; VAS, visual analog scale.

Note: The values are given as the median and interquartile range. p-Values were assessed using Wilcoxon rank-sum test.

Table 3 Radiographic findings 1 year postoperatively

Batra score (points)	Radial angle (degree)	Radial length (mm)	Volar tilt (degree)	Incongruency (mm)	Radioulnar joint (mm)
88 (78, 95.5)	21 (20, 23.3)	11 (9, 12)	2.5 (0, 10)	0 (0, 0)	0 (0, 0)

Note: The values are presented as median and interquartile range.

Table 4 Radiographic outcome according to Batra

Groups	Anatomical score	No of cases
Excellent	100–90	34
Good	89–80	21
Fair	79–70	8
Poor	<70	11

with the pi-plate. The wrist extension in our study was 50 degrees (76% compared with the uninjured side). These findings are better compared with the findings in other studies on combined plating.^{14,15,24,25} Landgren et al reported a wrist flexion of 65 degrees and extension of 63 degrees in a randomized controlled study in a group of AO type A and C fractures treated with fragment-specific fixation with similar results for another group treated with volar locking plates which is better than the flexion and extension in this study.²⁶ This could indicate that wrist extension may be negatively affected by the dorsal exposure in combined plating, compared with the more limited dorsal approach in fragment-specific fixation.

The grip strength was 82% compared with the uninjured side which is lower than in Landgren's study on fragment-specific fixation and volar locking plates but better than the grip strength found in other studies on combined plating.^{14,15,25} The PRWE score in our study was somewhat

lower, indicating a better outcome than what was reported in another study on combined plating with a similar cohort of patients.¹⁵ The QuickDASH-score in our study was higher, indicating an inferior outcome, compared with the DASH-score reported by Landgren.²⁶ However, their study group of patients also included AO type A fractures in comparison to our material of only type C fractures. Interestingly, the PRWE and QuickDASH scores were significantly lower, indicating a better functional outcome, in the older patient group compared with the younger, but both groups had a median Batra radiographic score of 88. There was no significant difference between the groups regarding grip strength or ROM, except for ulnar deviation which was somewhat better for the older patient group. In addition, the older patient group had significantly lower VAS pain scores compared with the younger group. A possible explanation for these findings may be related to decreased functional demands on the wrist associated with aging.²⁷ A randomized prospective study comparing volar plating and casting for intra-articular DRFs in elderly patients found a better outcome for volar plating compared with casting.²⁸ In contrast, a study comparing volar plating for intra-articular DRFs in younger and older patients found no difference between younger and older patients regarding DASH score, PRWE score, ROM, grip strength, or VAS pain scores.²⁹ Articular incongruency has been linked to the development of degenerative changes but these have not been consistently linked to compromised function.^{30,31} Our study failed to demonstrate a correlation

Table 5 Wrist function 1 year postoperatively, patients over/under 60 years of age

Outcome measure	Patients ≤60 y	Patients ≥61 y	p-Value
Sex male/female	11/23	8/32	NS
Pronation	94%	94%	NS
Supination	94%	94%	NS
Volar flexion	71%	78%	NS
Dorsal extension	74%	80%	NS
Radial deviation	80%	82%	NS
Ulnar deviation	79%	83%	0.014
Grip strength (kg)	83%	86%	NS
Pinch grip (kg)	85%	89%	NS
Key pinch grip (kg)	95%	93%	NS
VAS at rest (mm)	0.0 (0, 1)	0.0 (0, 0)	0.044
VAS during activity (mm)	3 (2, 5)	2.0 (0, 3)	0.001
PRWE score (points)	27.8 (14.0, 39.4)	10.5 (3.3, 22.9)	0.001
QuickDASH score (points)	22.7 (9.1, 37.0)	9.1 (2.3, 22.2)	0.006
Batra score	88 (85, 100)	88 (71, 94)	NS

Abbreviations: NS, nonsignificant; PRWE, patient-rated wrist evaluation; QuickDASH, quick disabilities of the arm, shoulder, and hand; VAS, visual analog scale.

Note: The values are given as the median and interquartile range. Values for range of motion and grip strength, key pinch, and pinch grip are expressed as mean percentage of the uninjured side. *p*-Values were assessed using Mann-Whitney U test. *p* < 0.05 was considered statistically significant.

between the radiographic outcome and the patient-related outcome measures as well as the AO fracture types and patient-related outcome measures. This finding is in line with a recent study assessing factors predicting adverse outcome in complete intra-articular DRFs where there was no correlation between the radiographic outcome and the clinical outcome measures.³² One explanation for this may be that the patient number in our study is too small to detect a difference between the groups. Another explanation may be that secondary skeletal changes due to a suboptimal radiographic outcome take some time to develop. A 1-year follow-up may be too short to detect this. A recent study by Miyashima et al found involvement of the dorsal ulnar facet fragment in 87% of AO type C3 fractures.³³ In our experience of managing complex intra-articular fractures, placing a volar locking screw in the dorsoulnar fragment in a comminuted unstable DRF can be technically challenging given the size of the fragment, often in combination with metaphyseal comminution. Combined plating offers the advantage of being able to reduce and stabilize the volar ulnar facet with the volar locking plate and thereafter addressing the dorsal fragments, including the dorsoulnar fragment, with

the dorsal plate. Considering the fact that all fractures in our study were AO type C, we believe the results regarding the radiographic findings, with a median Batra score of 88, are encouraging.

One drawback in our experience with the volar plate used in this study (the Medartis 2.5 TriLock Distal Radius Frame Plate) is that in some cases with volar comminution and the fracture extending proximally, the plate can be too short to allow adequate proximal fixation in the radius shaft. In these cases, a longer volar plate has to be utilized. Another potential drawback is that the volar plate is quite straight, compared with the slightly curved volar surface of the distal radius. This can make it technically difficult to fully restore the correct anatomic volar tilt of the distal radius when applying the dorsal frame plate and reducing the fracture fragments using the volar plate as a fulcrum. The radiographic finding of a median volar tilt of 2.5 degrees supports this. A study on a similar group of patients (80 cases of AO type C fractures) using combined plating with the now discontinued DePuy Synthes pi-plate system found a volar tilt of 6 degrees which represents a somewhat more anatomical result.¹⁵ A limitation of the study is the retrospective design. However, data were registered prospectively 1 year postoperatively as part of the clinic's routine. Not all patients completed the 1-year radiographic examination and instead, the Batra score was assessed on radiographs 3 months postoperatively. We believe this is acceptable given that the number of patients lacking 1-year radiographs was low and that the fractures showed bony union at the 3-month follow-up. Previous studies have raised some concern regarding tenosynovitis and a high rate of hardware removal using combined plating with the DePuy Synthes pi-plate.³⁴ We believe the rate of hardware removal in our study is acceptable. Flexor tendon injury following distal radius plating is a recognized complication.^{35,36} We thus believe the fact that there were no tendon ruptures or CRPSs in our study with only AO type C fractures, is encouraging.

In patients with complex AO type C intra-articular fractures, surgical fixation is often the treatment of choice. Despite the large number of studies available on the management of DRFs, the optimal fixation method remains debated. We believe anatomical restoration to be essential and for complex unstable intra-articular cases, combined dorsal and volar fixation is our treatment of choice. The question of optimal fixation of complex intra-articular fractures could be addressed with well-designed randomized studies, preferably multicenter studies comparing volar plating, fragment specific plating, and combined plating. This could help clarify the role of combined plating in relation to volar locking plates and fragment-specific fixation in modern hand surgery.

Ethical Approval

The study was approved by the Swedish Ethical Review Authority number 2019-00089.

Conflict of Interest

None declared.

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