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ORIGINAL ARTICLE

Functional Outcome and Complications at 2.5 Years Following Volar Locking Plate Fixation of Distal Radius Fractures

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Abstract Distal radius fractures are increasingly treated by internal fixation, but there have been relatively few studies relating to functional outcome at 12 months or more. The aim of this study was to ascertain the patient reported function of the wrist at a minimum of 12 months following fixation of a distal radius fracture, the time taken to return to work, and the complication rate. We conducted a retrospective review of 187 consecutive patients treated by a specialist hand and wrist trauma team at a tertiary referral unit over a 5 year period. Mean age was 57.3 years (range 16–93). Median time to surgery was 4 days (interquartile range 2–9). Median follow up was 31 months (interquartile range 23–41 months). The median PRWE score was 3; (range 0–83). There was no difference in outcome in patients who had surgery delayed by greater than 2 weeks ($p>0.05$). The median time to return to work was 5 weeks (interquartile range 1–8 weeks). There were 15 complications (8 %) including 3 tendon injuries. We have demonstrated an early return to work in patients who were employed, a low complication rate, and highly favourable functional outcomes at a mean of 30 months post-operatively. We recommend the use of the DVR plate and involvement of a dedicated hand and wrist trauma team for treatment of unstable fractures of the distal radius.

Keywords Distal radius fracture · Locking plate · PRWE · Outcome measure

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Introduction

Fractures of the distal radius are common injuries [1] with displaced and/or intra-articular fractures with joint incongruence frequently requiring operative fixation to achieve a good outcome. A range of treatment options are available to surgeons, most commonly including closed reduction and application of cast, percutaneous wire fixation [2], external fixation [3–5], and open reduction and internal fixation [6–8]. There has been debate as to the ideal treatment modality in unstable injuries as no clear evidence for any one treatment has been demonstrated.

In recent years there has been a shift towards anatomically contoured volar locking plates, which have the advantage of providing metaphyseal fixation with the implant residing on the concave volar surface of the distal radius. Placement at this site reduces the risk of dorsal soft tissue irritation previously seen in dorsal plating systems (e.g. Pi, dorsal, columnar) and makes use of an anatomical recess, which reduces the risk of flexor tendon irritation.

Good clinical results have been reported with volar locking plate devices [6, 7]. Furthermore, comparative clinical data examining the use of locking plate devices versus percutaneous treatment [9] and external fixation [10] has also been favourable, demonstrating an earlier return to a higher level of function. A number of authors have examined the biomechanical advantages of volar plating over other devices, also with favourable results [11–14].

There are relatively few studies in the literature relating to results of treatment by dedicated hand trauma teams. The more widespread use of volar locking plates and an increase in the volume of fractures being treated with internal fixation has lead to hand surgeons performing this procedure with increased frequency. It was noted in our unit that the complication rate following internal fixation of distal radius fracture was lower than that reported in the literature, and many patients were achieving an early return to work, highly satisfied with their outcome and with good level of function. The aim of this study was to ascertain the patient reported function of the wrist at a minimum of 12 months following fixation of a distal radius fracture, the time taken to return to work, and the complication rate, in patients treated exclusively by hand surgeons in a specialist hand and wrist trauma unit.

Methods

We retrospectively reviewed the first 259 consecutive patients presenting with an unstable fracture of the distal radius to the Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, UK, treated by internal fixation using a volar locking plate. Inclusion criteria for this study included adult patients, fracture of the distal end of the radius, no contraindications to surgery. Fractures were deemed unstable if there was significant dorsal comminution, if there was a displaced intra-articular component to the fracture, or if closed reduction and cast application had been attempted but failed or had redisplaced. Patients meeting these criteria underwent fixation with a volar locking plate (DVR plate, Biomet, Bridgend, UK - see Fig. 1). A small number of patients underwent fixation with an alternative implant if there was extensive diaphyseal involvement or if the correct size or side DVR plate were not available. Exclusion criteria included fractures fixed with another implant, fractures of the radial shaft and patients not treated by the hand and wrist team.

All patients were admitted via the hand and wrist trauma clinic at our institution, or as tertiary referrals from other hospitals within the region. Decision to manage injuries with internal fixation was made by a consultant surgeon and patients were operated on the next available operating list. Patients with 3 of the following criteria were offered surgery: a significant articular step (2 mm or greater), significant dorsal comminution, dorsal angulation greater than 20°, ulna styloid fracture and age greater than 60. Most patients were treated within 2 weeks of injury unless other circumstances prevented this (e.g. late presentation, unavailable operating list, secondary procedure after failure of primary procedure). All procedures were conducted by, or under the supervision of, one of the consultant orthopaedic surgeons with a specialist interest in hand surgery.

Patients were counselled preoperatively by a member of the surgical team regarding the risks and benefits of surgery, and informed consent was obtained. The procedure was performed under general anaesthesia or regional anaesthesia, under tourniquet control at 250 mmHg, with patients supine and the arm on an arm-table.

All patients underwent fixation via a volar approach (see Fig. 2), using the flexor carpi radialis (FCR) approach described by Orbay [15]. Having exposed the distal radius, the metaphyseal fracture fragments were denuded sufficiently to allow anatomical reduction. This was generally performed by elevation of the periosteum across to the sigmoid notch and to the radial side to expose and subsequently reduce separate radial styloid fragments. Release of the brachioradialis tendon was performed as necessary to facilitate reduction of radial translation of the metaphysis or of a separate radial styloid fragment.

The metaphyseal region was fixed to the plate first, to allow levering down of the fracture fragments before fixation to the shaft, facilitating restoration of volar tilt (see Fig. 3). This was also done with initial K wire fixation to the plate of all main fragments, followed by metaphyseal peg insertion. After fluoroscopic check of plate and screw placement relative to the wrist, the plate and metaphysis were subsequently levered down to the level of the shaft and secured with screws using eccentric drilling of the direct compression holes to increase radial length as required. After a further fluoroscopic check, to ensure adequate restoration of anatomy, including both length and metaphyseal tilt, final shaft screws were subsequently inserted. As a rule, unicortical drilling of the metaphysis was used in all cases to prevent extensor tendon damage.

Following skin closure a dorsal plaster of paris (POP) splint was applied and patients were discharged when comfortable the following morning. On occasion patients were discharged the same day if they were operated on in the morning and were comfortable later that day. All patients were seen prior to discharge by a member of the hand therapy team and given a series of passive and active movements of the fingers, and advice regarding elevation in the initial postoperative period and the need for compliance with rehabilitation protocol to gain an optimal outcome. POP splints were removed at

Fig. 1 The Distal Volar Radius (DVR) plate

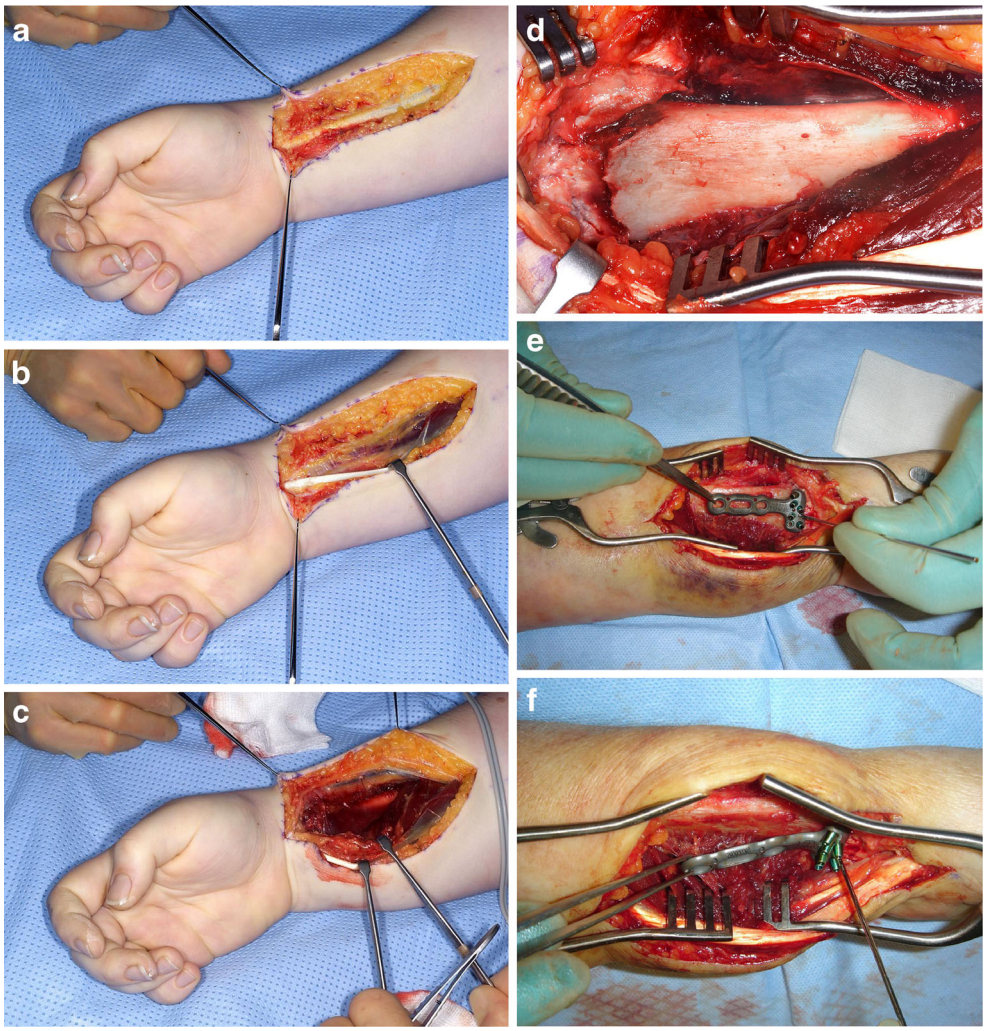

Fig. 2 **a** The FCR approach using a longitudinal incision over the FCR tendon. **b** FCR tendon is retracted ulnarward and the deep fascia is divided. **c** The flexor compartment musculature is bluntly swept ulnarward. **d** The pronator quadratus is then incised in an L shape along the watershed line to reveal the metaphyseal fragments. **e** An appropriately sized plate is selected and its size and position checked fluoroscopically. **f** Metaphyseal fixation is achieved initially and the plate used to lever the distal fragment down to restore volar tilt

2 weeks for wound examination, and a removable wrist splint was then applied until the 6 week clinical review.

Patients were followed up clinically at 6 and 12 weeks, and at 6 months and 1 year. Data relating regarding return to work and early complications were compiled prospectively. Patients were subsequently sent a questionnaire at the time of conducting this study including a patient related wrist evaluation (PRWE) questionnaire, a patient satisfaction score, and questionnaire relating to any complications that may have occurred between clinic discharge and the questionnaire being sent. Data were compiled and statistics were calculated using Microsoft Excel.

Results

259 patients were initially included in the study, of which 187 responses were received for the questionnaire. The response rate was 72.2 %. The patients who did not respond to postal questionnaire were subsequently excluded from the study. The 72 patients excluded from the study were of comparable age and sex distribution.

The mean age of the patients was 57.3 years (Range 16–93). The median inpatient stay was 1 day, (range 1–6, mode 1 day). Median time to surgery was 4 days (interquartile range 2–9). Median follow up was 31 months (interquartile range 23–41 months). Using the AO classification, 56/187 injuries were type A3, 4/187 type B1, 15/187 type B2, 19/187 type C1, 41/187 type C2, and 52/187 were type C3 (see Table 1).

The mean PRWE score at the time of follow up questionnaire was 12.2 (range 0–86; standard deviation 19.29). Median PRWE score was 3 (see Fig. 4).126/187 patients had an excellent outcome (PRWE score ≤10, 67 % 16/187 had a satisfactory score (PRWE score 11–20, 9 %), and 45/187 achieved a poor score (PRWE >20; 24 %) (see Table 2). A total of 14 patients experienced a delay between injury and surgery of greater than 14 days. In these patients, mean PRWE was 26 (range 0–90). There was no significant difference in PRWE score between delayed patients and those operated on within 14 days (Mann Whitney U; p=0.9). 71 out of 78

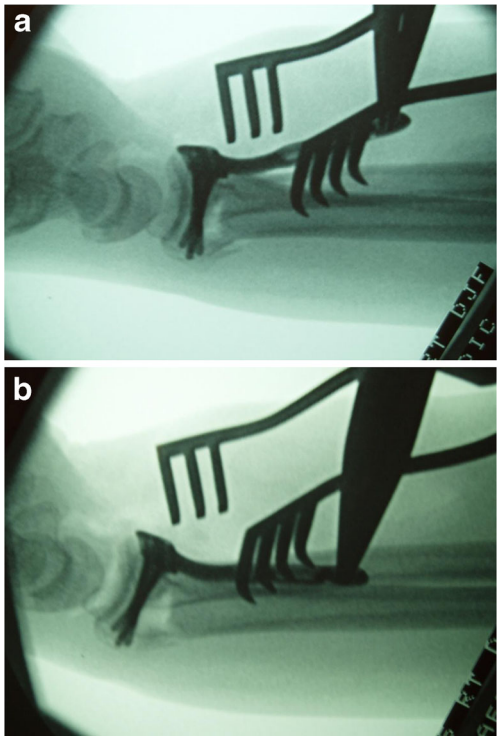

Fig. 3 **a** metaphyseal fixation prior to restoration of tilt. **b** The plate is used to lever the metaphysis volarwards to restore articular tilt

patients (91 %) returned to the same means of employment as before surgery. Of the patients who were returning to work, the median time to return to work was 5 weeks (interquartile range 1–8 weeks). There was no difference in outcome in patients who had surgery delayed by greater than 2 weeks ($p>0.05$).

There were 15 complications in total (8 %). Six (3.8 %) patients had extensor tendon irritation, of which two patients required surgery using an extensor indicis proprius transfer. One further patient had a spontaneous EPL rupture, which was not associated with prominent metal work, also requiring tendon transfer. Five (2.7 %) patients had symptoms relating to median nerve compression postoperatively. Of these, two patients underwent carpal tunnel decompression with complete resolution of symptoms. The other three settled spontaneously. Two (1.2 %) patients developed Complex Regional

Table 1 Fracture classification (AO)

AO classification	No. of pts (n=187)	% of pts
A3	56	30
B2	4	2
B3	15	8
C1	19	10
C2	41	22
C3	52	28

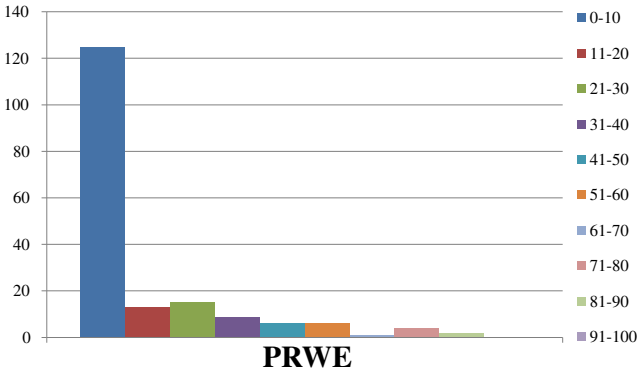

Fig. 4 Patient related wrist evaluation scores postoperatively (mean follow up time 31.8 months)

Pain Syndrome (CRPS), requiring referral to a pain management clinic and additional physiotherapy, which settled within 6 months. One patient developed a minor superficial wound infection.

In all, 11 (5.9 %) patients had removal of their metalwork, 6 for tendon irritation, 4 for wrist stiffness, and 1 for peg penetration into the joint.

A casenote review of patients excluded from the study revealed a satisfactory outcome in 54/72, who were discharged after 12 weeks. A further 2 patients were listed for plate removal due to stiffness and 1 underwent carpal tunnel release due to due symtoms of persistent median nerve compression. The remaining 15 cases had no available records due to non-attendance or follow up elsewhere.

Discussion

A number of authors have reported good results following internal fixation of the distal radius using this technique. Orbay and Fernandez [16], in their original series of 31 fractures in 29 patients reported excellent results in 19 and good in 12 according to Garland and Werley functional scales, at a mean follow up time of 12.5 months postoperatively. In a

Table 2 Patient related wrist evaluation (PRWE) score

PRWE score	No .of pts (n=187)
0–10	126
11–20	16
21–30	18
31–40	8
41–50	6
51–60	6
61–70	2
71–80	3
81–90	2
91–100	0

further study reviewing outcomes in an elderly patient group aged over 75 years, similarly good clinical data was reported, with final mean range of motion (mean) of 58° dorsiflexion, 55° volar flexion, 80° pronation and 76° supination [17]. Ibrahim et al. treated 129 patients treated with a DVR plate for dorsally displaced distal radius fractures the authors noted a comparative ROM of 70 %, 88 %, and 98 % compared with the contralateral side at 6, 12 and 26 weeks postoperatively. The mean PRWE score demonstrated only minimal disability at 26 weeks [18]. The present study, which has the largest study population treated with a DVR plate analysed to date, with the longest follow up time, shows comparable results, with the majority of patients scoring 0–10 on PRWE. It is worth noting that the mean time taken to return to work, in patients who were employed, is shorter in the present series than most in the literature. Furthermore, few studies have reported outcomes at greater than 12 months, and our data demonstrate that good results appear to be maintained for considerably longer than 12 months, which is the follow up time seen most commonly in comparable studies. Several other authors have reported good clinical outcomes, but without reporting on return to work [19, 20].

Despite positive results for internal fixation, debate exists as to whether this technique represents first line treatment for displaced, unstable fractures. Marcheix compared palmar fixed angle locking plate fixation to Kirshner wire fixation in a prospective randomized trial, reporting improved functional results (DASH and Herzog scores), with a plate, with better maintenance of reduction [21]. However, equivalent functional scores have also been reported when comparing locking plate fixation to external fixation [22, 23], or to conservative treatment [24]. The latter of these studies, however, was in an elderly group of patients. We have shown in the present study that internal fixation following distal radius fractures allows a return to a normal, or near normal, level of function in approximately 6 weeks with a return to work at a mean of 40 days.

The complication rate following locked volar plating of distal radius fractures is variable. Bentohami et al. have reported an overall complication rate of 16.5 %, in a systemic review of outcomes and complications following DRF fixation. [25]. We have noted an incidence of complications of 8 %, reflecting a low overall complication rate owing to a lack of flexor tendon injuries and a lower rate of CRPS than other studies. Flexor tendon injury following DRF fixation has been reported by various authors [25–27] with prominence of the plate and poor implant placement implicated in the aetiology of this complication [28–30]. In the present series we have noted an incidence of flexor tendon injury of 0 % at a mean follow up time of 30 months and a minimum of 12. It is worth noting that with a response rate of 72.2 % some cases may have been missed due to the methodology of the study. However, in our opinion, the absence of flexor tendon problems in the 187 cases studied is likely to be a reflection of the plate design, and accurate positioning intra-operatively. The DVR plate has a thin distal metaphyseal edge which sits up to the watershed line in the concavity of the volar metaphysis of the distal radius, ensuring little or no implant prominence if the implant is positioned correctly.

We have seen an incidence of extensor tendon injury of 3.8 %, which is lower than figures reported in the literature. Al-Rashid et al. [31] reported an incidence of extensor tendon rupture of 8.6 % of 35 cases (three cases) treated with an AO volar locking plate, citing screw penetration of the dorsal cortex and careless drilling technique as principle causes. Other authors reporting extensor tendon irritation and ruptures have cited similar reasons [32–35]. It is worth noting that extensor tendon injury has also been reported in 5 % of undisplaced distal radius fractures, most likely due to extensor irritation over dorsal callus formation [36]. The cases we have seen with extensor ruptures in this study both had prominent pegs at the level of the dorsal cortex. A third spontaneous rupture was seen, not relating to prominent hardware, which may be related to irregular dorsal cortical bone during fracture healing or due to a vascular insult at the time of injury. The lower incidence of extensor problems in the present study is likely to be reflection of our default operative technique, with unicortical drilling of the metaphysis and careful measurement of screw length, ensuring minimal risk of extensor compartment penetration by either drill bit or screw. Despite the policy of unicortical drilling, two extensor tendon injuries were seen in relation to prominent pegs dorsally, which highlights the need for great care both when drilling and when measuring peg/ screw length.

The relatively low percentage of cases complicated by CRPS (1.2 %) postoperatively is likely to be due to the early mobilisation and involvement of dedicated hand therapists from the immediate postoperative period. All cases were operated on by surgeons with a subspecialty interest in hand and wrist trauma, and it is also likely that efficient technique and careful handling of tissues contributed to the low incidence of CRPS.

We acknowledge a number of clear limitations to our study. The retrospective design of a questionnaire study has meant that a higher proportion of cases than we hoped were lost to follow up. Additionally, this has meant that functional outcomes have been assessed using a patient assessed outcome measure, which in turn has resulted in a loss some objectivity in data collection, as well as the loss of accurate measurement of range of movement data. However, in our opinion, accurate representation of wrist motion is of limited relevance, as a return to normal activity and function is of greater importance, both reported here. Moreover, the functional results seen in this study are highly favourable, at a mean follow up time which is amongst the longest in the literature. The absence of a control group in the study has also limited the conclusion that

can be drawn, and further prospective and comparative studies are needed to ascertain whether dedicated hand and wrist trauma teams achieve improved outcomes compared to general trauma teams.

We recommend involvement hand and wrist surgery teams and attention to unicortical drilling and correct plate placement in the operative treatment of unstable distal radius fractures. With this strategy we have shown a favourable complication rate and excellent functional outcomes, with an expeditious return to work in those who are employed, compared with other studies reported in the literature.

Statement of Ethical Standards All human studies were approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All persons included in the study gave their informed consent prior to their inclusion.

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