Original article
Orthopaedics

FUNCTIONAL AND RADIOLOGICAL OUTCOMES AFTER VOLAR LOCKING PLATE FIXATION IN TYPE C DISTAL RADIUS FRACTURES – A RETROSPECTIVE STUDY

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Article submitted on: 29 April 2018
Article Accepted on: 03 May 2018

Abstract:

Background - Open reduction and internal fixation using a volar locking plate has gained popularity for the treatment of intraarticular distal radius fractures.

Purpose - To evaluate the functional and radiological outcomes of unstable intraarticular distal radius fractures after fixation with the volar locking plate.

Patients and methods - A retrospective review was conducted of patients using the volar locking plate to treat intra-articular distal radius fractures. Unstable intraarticular distal radius fractures in 22 patients, comprising 17 male and 5 female with a mean age of 54.4 years (21–71 years), were treated with a volar locking plate followed up for a minimum of 2 year. Fractures were classified using the AO classification. Radiological parameters of preoperative and final follow-up radiographs were compared. The time to initiation of active range of motion was determined. Final follow-up range of motion and complications were reported.

Results - At final functional assessment, all patients have good range of motion of wrist and no patient has severe pain according to the Fernandez pain score. In all patients radiological parameters are in acceptable range at final follow up. No non-union or implant failure occurred. Flexor tenosynovitis is important complication in 2 patients for which implant removal was done.

Conclusion - Irrespective of the direction and amount of initial displacement, a great majority of intra-articular fractures of the distal radius can be managed with a fixed angle volar plate. It leads to satisfactory clinical outcome and radiological results, provided the operative technique is carefully performed to prevent complications.

Keywords: *Complications of locking plate, distal radius fracture, volar locking plate*

Introduction

Fractures of the distal radius and/or ulna are the most common fractures of the upper extremity.[1] There is as yet no universally accepted classification.[2] We have to consider some important points when we assess and plan our treatment strategy for these fractures. Important points are:

- Fracture displacement and Communition
- Articular involvement
- Associated ulnar fracture or disruption of the distal radioulnar joint
- Osteoporosis

Equally, in evaluating radiographs the following parameters are noted[3,4] :

- Radial length (Normal value -11 -12mm)
- Radial inclination (Normal value 22-23 degrees)
- Volar / palmer angulation (Normal value 11 – 12 degrees palmer tilt)
- Intra-articular step-off or gap

Factors such as handedness, age, functional requirements, co-morbid conditions and other injuries (open wounds, tendon rupture, neurological or vascular injury) are also taken into account.[5] There have been many studies to identify factors predictive of fracture instability in order to aid management decision.[6-10] These studies may have identified certain risk factors for instability. In conclusion, fracture instability is multi-factorial and not solely dependent on radiographic parameters.

Non operative treatment with plaster or splint is usually advised for undisplaced or reducible and stable fractures. Patients with fractures not fulfilling the above criteria are often candidate for surgical treatment. Options include percutaneous k wire fixation, external fixation and open reduction internal fixation with a variety of implants. Plates have the advantage of providing fixation without protruding wires or pins, which transfix soft tissues & allow earlier rehabilitation. Disadvantages include more surgical trauma, risk of fragment devascularisation, tendon irritations and ruptures, scar and impingement.

In the past few years, the rate of non-operative treatment of these injuries has decreased, just as the rate of internal fixation, and particularly of volar locking plate fixation, has increased dramatically.[11] Many studies documented a number of theoretical advantages of volar locking plate fixation and good outcome.[12-17]

The purpose of this study is to ascertain whether the use of volar locking plates resulted in:

- Improved functional outcomes
- Improved radiographic results

Material and methods

Twenty two patients with intraarticular Type C distal radius fractures were treated with volar locking distal radius plate from April 2015 to March 2016. Open reduction and internal fixation with the volar locking plate was performed via a volar approach through the flexor carpi radialis flexor sheath, under fluoroscopic guidance. We excluded all distal radius fractures that presented with

1. Type A (extraarticular) and Type B (partial articular) distal radius fractures
2. Radiocarpal fracture dislocations,
3. Dorsal articular impacted fractures with intact or nondisplaced volar cortex,
4. Massive intra-articular communition and/or bone loss (i.e., more than five intra-articular fragments)
5. Distal radius fractures extending to the shaft of the radius, and concomitant fractures of the same limb
6. Bilateral distal radius fractures

This study included 17 male and 5 female with an average age of 54.4 years (range 21 years to 71 years). 10 patients had fractured their dominant wrist, and 12 patients fractured their non-dominant wrist. Out of 22, 15 patients sustained their injury after a simple fall on an outstretched hand. The remaining were work-related accidents, road traffic accidents, and sports injuries. The time interval between the injury and fracture fixation was on average 6 days (range, 0–11 days). Out of the 3 open fractures, 2 were classified as Gustillo grade 1 and 1 was Gustillo grade 2 fractures. All of the patients gave informed consent for surgical treatment. Fractures were classified using the AO classification system.[18] (Table 1)

Table 1 The distribution of the severity of intra-articular fractures of distal radius based on AO classification[18]

AO type C classification of distal radius		No of patients
C1	Simple intra-articular fracture with simple metaphyseal involvement	4
C2	Simple intra-articular fracture with multifragmentary metaphyseal configuration	10
C3	Multifragmentary intra-articular fracture	8

All procedures were performed under general or regional anesthesia

with tourniquet. The distal radius was exposed by a palmar approach along the flexor carpi radialis tendon. After lifting of the pronator quadratus muscle from its lateral insertion, the fracture site and volar surface of the distal radius were exposed. Fracture reduction was verified with the image intensifier. Provisional Kirschner wires were used occasionally. The pronator quadrates muscle was repaired. Physiotherapy was started immediately. (Figure 1 and figure 2)

Figure 1 – Preoperative xrays

Figure 2 – Postoperative xrays

Distal radioulnar joint (DRUJ) instability was tested in all cases intraoperatively after the fixation of the distal radius. DRUJ instability was arbitrarily defined as an increase in the anteroposterior translation of 5–10 mm as compared with the uninjured wrist and a soft endpoint[19] when tested after the plate fixation of the distal radius. Two patients were noted to have DRUJ instability and fixed with k wires.

Preoperative and final follow-up volar or dorsal angulation, radial inclination, and radial length were measured radiographically. For radiographic evaluation, standard anteroposterior (AP) and lateral X-ray images were taken of both wrists, with the parameters measured by ruler in millimeters based on Castaing.[20] The preoperative radiographic evaluation showed an average dorsal tilt of 23° (range, 30° volar tilt to 60° dorsal tilt), an average radial inclination of 9.5° (range, – 10° to 35°), and an average radial shortening of 4.4 mm (range, 0 to 12 mm). Articular incongruity averaged 4.0 mm (range, 1 to 10mm).

The follow-up protocol was at 2 weeks, 6 weeks, 3 months, 1 year, and 2 years. Clinical and radiographic assessments were performed at every visit. The clinical outcome was evaluated with the following parameters: range of motion of the wrist and fingers, pain according to the Fernandez pain score (Table 2)[21]

Table 2
Degree of residual wrist pain, described by the patients

Degree of pain	Description
None	Absence of pain in carrying out all activities
Mild	Presence of pain only at the extreme(s) of the active range of motion of the wrist No physical or psychological disturbance was noted
Moderate	Presence of pain during heavy manual labor. Either physical or psychological disturbance or both was noted
Severe	Presence of pain occurring during activities of daily living and even at rest

Finger range of motion was assessed by measuring the distance from the fingertips to the distal palmar crease; wrist and forearm motion was measured with a goniometer. Bone healing was defined as the presence of bridging bony trabeculae across the fracture lines on both the PA and lateral views.

Results

The follow-up protocol was at 2 weeks, 6 weeks, 3 months, 1 year, and 2 years. For the majority of cases, full finger motion was achieved at the end of the two week, and satisfactory forearm rotation was achieved by 8 weeks postoperatively.

At 2 years' follow-up all patients had achieved full finger range of motion. The mean wrist motion was as follows: 54° of extension (range, 36–84°), 51° of flexion (range, 40–75°), 24° of ulnar deviation (range, 14–40°), 16° of radial deviation (range, 10–26°), 75° of pronation (range, 60–90°), and 77° of supination (range, 30–90°). (figure 3)

Figure 3
Patient showing good range of motion of wrist

Twelve patients had no pain, 7 patients had mild pain, and 3 patients had moderate pain according to the Fernandez pain score.[21] 10 Of the 22 fractures that suffered with

Mild and moderate pain, all had a C2 or C3 fracture pattern. (Table 3)

Table 3
Relationship between degree of pain and AO fracture type

Degree of pain	C1	C2	C3
None	4	5	3
Mild	0	5	2
Moderate	0	0	3
Severe	0	0	0

Additional chondral damage with communition and nonrecognized carpal ligament injuries might explain the persistence of discomfort and pain. All patients who were employed at the time of injury, were able to return to work within 24 weeks of injury (depending on the nature of their work; all were able to return to their preinjury daily activities.

Radiologically, all fractures healed with an average time to bone union of 14weeks (range, 12–17weeks). At final follow-up, the average volar tilt was 7° (range, 2° of dorsal tilt to 15° of volar tilt), radial inclination averaged 21° (range, 12–28°), radial shortening averaged 0.8 mm (range, 0–2 mm), and articular congruity averaged 0.15 mm (range, 0–2mm).

Discussion

The primary goal in treatment of unstable intraarticular fractures of the distal radius is to achieve anatomic reconstruction of the disrupted anatomy and allow the quick return of function to preinjury status without complications.

Dorsal plate fixation is claimed to be biomechanically effective in buttressing a dorsally displaced fracture of the distal radius.[22] Leung et al[23] demonstrated that volar locking plate showed advantages over dorsal plating in the fixation of a dorsally unstable distal radius fracture. The anatomy of the distal radius itself favours to a volar approach for internal fixation. The volar surface of the distal radius in the metaphyseal region is relatively flat. The dorsal cortex is thin, which often results in comminution and subsequent dorsal tilt, while the volar cortex is thicker, stronger and typically less comminuted in dorsally angulated fractures. This makes restoration of anatomy and alignment easier[16] and provides an excellent base to fix an implant. Anatomical reduction of the palmar cortex may avoid the shortening of the radius, which is important for its restoration. In our series, final Radial length was reconstructed to excellent level, and resulted in a wide range of motion.

There is also more space on the volar aspect of the wrist. Flexor tendons are located away from the surface of the bone.[16] The pronator quadratus can also sometimes act as a barrier to prevent soft tissue irritation. The dorsal approach often needs dissection of the extensor retinaculum and sometimes resection of the Lister's tubercle. Therefore, the extensor tendons are generally exposed to mechanical attrition by the plate and screws. There is a volar concavity in the sagittal plane making a smooth curve from distal to proximal allowing plenty of space for an implant.[24] The distal edge of volar distal radius is marked by a transverse ridge or watershed line. Distal to this line the bone slopes dorsally and gives rise to the attachment of the volar wrist capsule and volar carpal ligaments. The plate must not project past this line to avoid irritation of, and injury to, the flexor tendons.[25] Volar fixed-angle locking plates for dorsally unstable radial fractures are strong enough to support the dorsal fragment and have sufficient stability to allow early active motion. This has been one of the main arguments for their exponentially increasing use.

Volar plate fixation of unstable distal fractures has been described recently.[24,26-30] Our results are comparable to the final follow-up range of motion, radiological parameters, and functional outcomes presented in these articles. In regard to complications, Orbay et al[27] reported 1 case among 31 of dorsal tendon irritation from an excessively long peg for which hardware removal was done. Of nine patients with preoperative median nerve symptoms who had carpal tunnel release, the final neurologic examination showed complete resolution at the time of late follow-up. Rohit et al[28] reported an overall 31 patients (27%) with complications. They considered tenosynovitis as a risk factor for progressive damage to the tendons and therefore included tenosynovitis as a complication. There were 17 tendon complications (57% of the total number of complications). Early hardware removal was performed in all patients who developed tenosynovitis. Among other complications, three patients suffered carpal tunnel syndrome (3%), screw loosening occurred in two patients (2%), and intra-articular screw displacement occurred in one patient (1%).

With regard to complications, in our series one patient developed a complex regional pain syndrome, and another had a mild superficial skin infection. There was no implant failure in any patient. Two patients had developed flexor tenosynovitis for which implant removal was done. The optimal placement of the distal row screws is important: they must be inserted at the radial styloid, beneath the lunate facet, and near the sigmoid notch.[31] Volar plates placed over or distally to the watershed line can exert pressure on the flexor tendons and cause injury.[28,32] Flexor pollicis longus

tendon is close to the palmar rim of the distal radius. The plate placed very close to the wrist joint can support the palmar aspect of the articular surface. However, it sometimes causes flexor tendon impingementment. In the very distal area, it is not possible for the reattached pronator quadratus muscle to protect the flexor tendons. As a result, the flexor tendons can rub against the plate and sharp edges of the screw heads. During implant removal in both cases plate had been found distal to watershed line. So this can be cause of tenosynovitis.

If fracture configuration demands distal placement of plate, close monitoring and plate removal should be considered at the first sign of flexor tenosynovitis as reported by Drobetz etal.[30] Flexor and extensor tendon irritation has also been reported in other studies as the most frequent problems.[28,30]

DRUJ instability is recognized as a poor prognostic factor in the treatment of distal radius fractures.[33] However, recent studies[34] have shown that if the distal radius fractures are anatomically reduced and rigidly fixed with locking plates, no significant difference is noted in the final outcome between patients with and without ulnar styloid fractures. If ulnar styloid fracture progresses to nonunion, no significant clinical difference has been noted when compared with patients with united ulnar styloid fractures.[35,36] There is no case of residual DRUJ instability or laxity after 6 weeks. No significant ulnar wrist pain has been noted at the final assessment in these patients. Two patients were noted to have DRUJ instability intraoperatively and fixed with k wires.

The shortcomings of the present study include the fact that it is retrospective, which introduces bias. There was no control group; hence, no conclusions can be made as to comparison with other types of treatment methods. The series was nonhomogeneous and included different patient groups ranging from simple articular to complex intra-articular fracture, which were not analyzed separately. Similarly, the patients with DRUJ instability or an ulnar styloid fracture represent a different cohort, which may confound the results. Nevertheless, this study demonstrates that with the application of good surgical techniques, proper plate positioning, proper insertion of screws, a satisfactory functional and radiological outcome can be obtained for a great majority of patients with complex intra-articular distal radius fractures by using a volar approach and a single locking plate.

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