Original Article

Radiographic and functional evaluation of low profile dorsal versus volar plating for distal radius fractures

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ABSTRACT

Introduction: Fracture of the distal radius is a common clinical problem. Complex fracture requires open reduction and stabilization with plating to restore anatomy. Dorsal plating has advantages of buttressing the fracture better but often complicated with tendon problems as per literature. The rate of complications however, was not compared between the low-profile dorsal and the volar plates.

Methodology: This was a retrospective study on seventy one patients with dorsally angulated or displaced distal radius fractures, who underwent fixation of fractures with either dorsal or volar locking plate from Jan – Nov 2012. Preoperative radiographs were classified based on Universal and Fernandez classification. Postoperative radiographs were assessed for anatomical restoration of Radial length, radial inclination and volar tilt. Tendon and nerve related complications were assessed and functional evaluation was performed on the basis of PRWE (Patient related wrist evaluation) score.

Results: Both groups were matched for their demographic profile and fracture types ($p < 0.033$). Dorsal plating group had 89% excellent/good restoration and fair in 11%. Volar group had 96% excellent/good restoration and fair in 4%. Statistical analysis was performed with unpaired t test for radiographic parameters.

Three patients had tendon related complications in dorsal plating group; two patients in volar group had nerve related complications. Functional outcome with PRWE was comparable between two groups.

Conclusion: Results with low profile dorsal plating were comparable to volar plating. Therefore dorsal plating can be used as an alternative method when dorsal buttressing of comminuted fracture is required, especially with concomitant osteoporosis.

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1. Introduction

The fracture of distal radius is the commonest fracture seen in emergency, constitute 17% of all fractures.¹ The fracture with dorsal displacement and angulation is usually caused by fall on the outstretched hand. There is little or no evidence based guidelines for the treatment. The outcome of these fractures is not uniformly good.²

Complex fracture requires open reduction and surgical stabilization to restore anatomy. Volar plating for dorsally displaced fractures has the problem that plate lying at the opposite site than the direction of displacement. The plate does not act as a buttress and the poor quality of bone in this area does

not give much grip for the screws to act as pulling screws, resulting in loss of reduction.² Volar plates are also complicated by neuropathic problems.⁵

Dorsal plating has advantages of buttressing the fracture but often complicated with tendon problems. Extensor tendons run directly over the implant and tendon problems with adherence and even rupture.³ However newer low profile plates with smooth titan polishing reduce the risk of tendon irritation. There is limited published evidence on this.

The biomechanical studies⁴ especially one published recently in 2012 does show some advantages with dorsal plate, while most previous studies with dorsal plate were associated with higher tendon related complications.⁵ These were performed using different types of plates, not necessarily low profile plates with smooth titan polish and mostly on small number of patients.^{6–9} I believe this perception will change with my study as there are lower complications with newer low profile dorsal plating.

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2. Aims

This is a study on dorsally displaced distal radius fracture fixed with either dorsal or volar plating to assess their clinical outcome, radiological assessment for anatomical reduction and complications.

3. Material and methods

3.1. Methodology

This is a retrospective study carried out on the patients with dorsally angulated or displaced distal radius fractures, who underwent fixation of their fractures with either dorsal or volar locking plate. Seventy one patients with fractures of the distal radius meeting above criteria were included in the study.

The important exclusions from the study were

- (1) Volar angulated and displaced distal radius fractures
- (2) Conservatively treated distal radius fractures
- (3) Paediatric age group
- (4) Associated radius ulna shaft fracture.

The decision to choose either dorsal or volar locking plate was taken by operating surgeon based on their preference, training and belief to give best possible results. The decision was based on their previous experience and was irrespective of fracture configuration and dorsal comminution. All surgeries were performed on scheduled trauma lists by experienced surgeon. Standard volar and dorsal approaches were used for reduction and fixation of fragments with low profile volar and dorsal locking plates. In the dorsal plating group the surgical approach involved a dorsal incision immediately ulnar to Lister's tubercle. The dorsal retinaculum was opened with a longitudinal incision. The fracture was exposed and stabilized provisionally with k wire after elevating the metaphyseal fragment. The low profile, anatomically contoured locking plate was then used to fix the fracture with appropriately sized screws. Reduction of fracture fragments was confirmed with image intensifier and images saved.

The modified Henry approach is performed through the flexor carpi radialis sheath utilizing the interval between Flexor carpi radialis tendon and radial artery. The extended carpal tunnel approach develops the interval between the finger flexor tendons and the flexor carpi ulnaris. This last approach allows for improved visualization of the ulnar side of the radius and is useful for reduction of unstable ulnar fragments. Postoperatively limb was elevated and active finger and wrist mobilization commenced earliest possible.

Radiographic evaluation of the postero-anterior and lateral views was performed for preoperative and postoperative films. Preoperative radiographs were assessed based on articular involvement, angulations and radial length.

Universal and Fernandez classification system was used to classify fractures into different types based on articular involvement.

- Type I: Non articular, non displaced
 Type II: Articular, non displaced
 Type III: Non articular, displaced
 Type IV: Articular, displaced.

Postoperative radiographs were assessed for anatomical restoration of Radial length, radial inclination and volar tilt in postoperative films.

3.2. Radial length

Radial length is measured on the Postero-anterior radiograph. It represents the distance between a line drawn at the tip of styloid process, perpendicular to the long axis of the radius and a second perpendicular line at the level of the distal articular surface of ulnar head. The average radial length is 11–12 mm.

3.3. Radial angulation or inclination

On the Postero-anterior view, inclination of distal radius is represented by a line drawn from the tip of the radial styloid to the ulnar corner of the articular surface of the distal end of the radius and a line perpendicular to the longitudinal axis of the radius. The average inclination is 21°.

3.4. Volar/dorsal inclination

On the lateral view, a line is drawn connecting the distal most point of the dorsal and volar rims. The angle that this line creates with a line perpendicular to the longitudinal axis of the radius reflects volar inclination. Average volar inclination is 11°.

Quality of reduction was classified based on Sarmiento et al.¹⁰ anatomical criteria radiographically. This scoring was based on comparing postoperative results to average parameters¹³ for good radiographic outcome i.e. radial length of 11 mm, radial inclination of 22° and volar angle of 11°.

Sarmiento's modification of Lindstrom criteria for anatomical evaluation (Table 1).¹⁰

Patients were followed for skin, tendon or nerve irritation and rupture related complications. Functional outcome evaluation was performed on the basis of PRWE (patient related wrist evaluation)¹² and Mayo wrist score.¹¹

4. Observations and results

4.1. Demographics

The study comprised a total of seventy one patients of dorsally displaced and angulated distal radius underwent open reduction and internal fixation with dorsal or volar locking plate from 1 January 2012 to 30 November 2012.

The mean age of the patients for the study was 58 years with the youngest patient being 17 years and the oldest being 91 years. Dorsal plating group had mean age of 60 years (range 17–86 years) and volar plating group with mean age of 54 years (range 23–91 years). There were 8 males and 36 females in the dorsal plating

Table 1
Sarmiento classification.

	Residual deformity	Loss of palmer tilt (°)	Radial shortening (mm)	Loss of radial deviation (°)
Excellent	Insignificant	0	<3	5
Good	Slight	1–10	3–6	5–9
Fair	Moderate	11–14	7–11	10–14
Poor	Severe	At least 15	At least 12	>14

Graph 1. Gender distribution.

Table 2
Demographics.

	Patients	Male	Female	Age min	Age max	Mean
Volar plating	27	4	23	23	91	54
Dorsal plating	44	8	36	17	86	60
All patients	71	12	59	17	91	58

group; 4 males and 23 females in the volar plating group (Graph 1, Table 2).

4.2. Classification

Preoperative radiographs for both dorsal and volar plating groups were classified on the basis of universal classification and Fernandez classification system (Graph 2).

4.3. Fernandez classification

Both groups showed no statistical significant difference (Sig 0.033) on Chi-squared test using SPSS (IBM) software (Table 3).

4.4. Duration of follow up

Patients were followed for 20–50 weeks for clinical and radiological assessment for union, complications and functional outcome.

5. Radiographic evaluation

5.1. Radial length

The mean radial length of the radial styloid was 5.44 mm and varied from –2 to 14 mm. In the dorsal plating group the mean length was 5.34 with range from –2 to 14. In the volar plating group mean length was 5.52 with range from –2 to 12 mm (Table 4).

Postoperatively the radial length was restored to a mean of 11.92 with range from 6 to 18 mm. In the dorsal plating group the mean radial length was 11.23 with range from 6 to 16. In the volar plating group mean length was 13.04, with range from 9 to 18 mm (Graph 3).

5.2. Radial inclination angle

The mean radial inclination angle of the distal radial articular surface was 13.2° and varied from –7 to 24°. In the dorsal plating group the mean radial angle was 13.45° with range from 2 to 22°. In the volar plating group mean dorsal angle was 12.74 with range from –7 to 24°.

Postoperatively the radial inclination angle was corrected to a mean of 22.04 with range from 9 to 29°. In the dorsal plating group the mean radial inclination angle was 21.32 with range from 9 to 27°. In the volar plating group mean radial inclination was 23.22, with range from 18 to 29° (Graph 4).

5.3. Dorsal/volar inclination angle

The mean dorsal inclination angle (from a neutral of 0°) of the distal radial articular surface was 19° and varied from 0 to 49°. In the dorsal plating group the average dorsal angle was 19.05° with range from 3 to 43. In the volar plating group mean dorsal angle was 19.37 with range from 0 to 49.

Postoperatively the dorsal tilt angle was corrected to the anatomical volar inclination angle of a mean of 5.16 with range from 9° dorsal to 16° volar. In the dorsal plating group the mean volar inclination angle was 4.23 with range from 8° dorsal to 16° volar. In the volar plating group mean volar inclination was 6.7°, with range from 9° dorsal to 15° volar (Graph 5).

5.4. Statistical analysis

Statistical analysis between two groups was performed with unpaired Student's *t* test and showed no statistical difference between radiographic parameters in 2 groups. The sample size was

Graph 2. Universal classification.

Table 3

Fernandez classification.

	Type 1	Type 2	Type 3	Type 4	Type 5	Totals
Dorsal plating	28	0	16	0	0	44
Volar plating	19	0	5	0	3	27

Table 4

Pre and postoperative mean.

	Preoperative mean			Postoperative mean		
	Length	Radial	Volar	Length	Radial	Volar
Volar plating	5.52	12.74	−19.37	13.04	23.22	6.7
Dorsal plating	5.34	13.45	−19.05	11.23	21.32	4.23
All patients	5.44	13.2	−19	11.92	22.04	5.16

calculated to be 26 patients based on mean values and standard deviation of radial lengths to the desired statistical power of 0.80.

5.5. Anatomical scoring

The scoring was according to the Sarmiento et al. anatomical criteria radiographically as described in Section 3.

In the dorsal plating group, 28 patients (64%) had excellent restoration of anatomy, 11 patients (25%) had good restoration, and 5 had fair (11%) restoration of anatomy. Thus 89% patients had excellent to good alignment at fracture and fair alignment in 11% patients.

In the volar plating group, 22 patients (81%) had excellent restoration of anatomy, 4 patients (15%) had good restoration and one had fair (4%) restoration of anatomy. Thus 96% patients had excellent to good alignment of fracture fragments and fair results in 4% patients (Graph 6).

5.6. Complications

There were tendon related complications in three patients in the dorsal plating group. One patient had tendon irritation because

of screw backing out as shown in Picture 1. Two patients required tenolysis and removal of plate between 30 and 35 weeks, and one patient was treated conservatively.

There were nerve and soft tissue irritation in two patients in the volar plating group, of which one required removal of plate and carpal tunnel decompression at 32 weeks and one treated conservatively. Complications in the volar plating group are comparable to complications reported in the literature (9%).¹⁹ Complications in the dorsal plating group have been variably reported in literature depending on type of plate, mostly studies on non low profile plates (Graph 7).

5.7. Functional scoring

The functional scoring of healed fracture was performed based on the patients related wrist outcome score (PRWE) and Mayo wrist score through postal questionnaires. We received response from twenty four patients, sixteen from the dorsal plating group and eight patients from the volar plating group. Mean PRWE score in the dorsal plating group was 21.5 (range from 0 to 97) and mean score in volar plating group was 15 (range from 0 to 45.5). Number of responses to postal questionnaire was not sufficient for

Graph 3. Radial length. **Graph 4.** Radial inclination angles.

Graph 5. Dorsal/volar inclination angles.

Graph 6. Anatomical scoring.

statistical analysis. Scores were also calculated and classified as per Mayo wrist score as per [Table 5](#).

6. Discussion

The distal radius fracture is common fracture seen in accident and emergency. The management of unstable displaced fracture is associated with significant challenges. There are several methods of fixation for unstable displaced fracture. The requirement is that the fixation method should not only maintain satisfactory reduction but also should allow early mobilization to avoid atrophy from disuse and joint stiffness.

Open reduction and internal fixation can be performed via either the volar or dorsal approach. Both the approaches have their pros and cons, dorsal plates are associated with tendon related problems and for volar plates extensive soft tissue dissection is required. The choice is dependent on degree of displacement and comminution. Volar plates have further problems that plate is laying on the opposite side to the fracture. For dorsally displaced fracture, the reduction is dependent on purchase of screws and strength in osteoporotic bone. The majority of studies have reported good outcome with both the volar and dorsal plates, but not shown complications associated with these plates. The majority of complications are associated with the soft tissue dissection of the involved structures. Most of these studies are performed on small number of patients and do not show any conclusive difference in outcome. A recent meta-analysis has shown no significant difference between two types of fixation method in terms of overall rate of complications.

Anatomical differences (particularly the proximity of tendons and nerves to the volar or dorsal plate) can contribute to different complication rates. A volar approach has been shown to be associated with median nerve compression and carpal tunnel syndrome, with some patients requiring carpal tunnel release during or after surgery.¹⁵ This is because the volar approach

Picture 1.

Graph 7. Complications dorsal versus volar plating.

involves retraction of the median nerve, which may directly (or indirectly) lead to neuropathy and carpal tunnel syndrome.⁷ Others have suggested a correlation between the volar approach and an increased incidence of postoperative neuropathic complications, although it was not possible to determine whether the incidence of carpal tunnel syndrome and major neuropathies was due to pre-existing carpal tunnel syndrome or to the volar approach itself.⁵ As the volar approach fixes the plate within anatomical structures (including the median nerve), it is likely that this may contribute to increased incidence of carpal tunnel syndrome and neuropathic complications, compared with the dorsal approach.

The dorsal approach is traditionally associated with a high rate of local irritation or tenosynovitis of the extensor tendon.^{15,16} as per published literature; the risk of tendon irritation was significantly lower with the volar than the dorsal approach. This may be explained by the anatomy: the volar diaphyseal cortex is protected by muscle but the dorsal cortex is not, leaving the extensor tendons at risk from any screw protrusion. A recent meta-analysis¹⁷ indicates that dorsal fixation offers a lower risk of neuropathy and carpal tunnel syndrome than the volar approach, but a higher risk of tendon irritation. In terms of other complications, patients with distal radius fractures can expect similar outcomes after volar or dorsal surgery.

Dorsal plating is also associated with higher rates of volar collapse. In a recent study published by Ruch et al.,⁹ volar collapse may occur regardless of the type of dorsal plate used and that volar plating is associated with fewer complications than dorsal plating. In the dorsal plating group there was a statistically significant association of volar collapse of the distal fragment when the distal screws were pointing proximally. The reason for this may be related to the biomechanics of the plate/screw construct applied to the dorsum of the wrist. The measurement of the angle that the distal screws make with the shaft of the radius highlights the limitations of dorsal plate application for preventing volar displacement. Distal fracture lines require that screws be directed proximally in the distal fragment. Such a construct relies on proximal shaft fixation to prevent dorsal displacement (buttress) and on obliquely oriented screws in the distal fragment to prevent volar displacement. If these distal screws are either perpendicular or directed distally in the fragment, as evidenced by a positive shaft screw angle, then there is significantly less likelihood that volar collapse would occur.

Table 5
Functional scoring.

	Excellent	Good	Satisfactory	Poor	Total
Dorsal plating	5	3	7	1	16
Volar plating	3	2	3	0	8

In the dorsal plating group the most common site of tendon irritation occurred radially at Lister's tubercle. The extensor pollicis longus had been released previously from the third dorsal compartment in all cases and therefore was not affected. The most commonly affected tendon was actually the extensor carpi radialis brevis; however, it was never ruptured completely, perhaps because of its girth. The index extensor tendon was the most commonly ruptured tendon because of its proximity to the radial limb of the plate.

Tendinitis and tendon irritation resulting in the need for plate removal has been reported in up to 20–33% of cases.^{3,14} In addition extensor tendon attritional rupture attributable to prominent hardware also has been reported and has been linked to both metallurgy and plate design.¹⁸ Rozental et al.¹⁶ retrospectively reviewed the results of dorsal plating in 28 patients treated with either a plate (Pi plate, Synthes) or a low-profile plate. The researchers concluded that the use of the plate resulted in a significantly increased risk of extensor tendon complications when compared with the low-profile plate. The rate of complications, however, was not compared between the low-profile plate and the volar plate.

7. Conclusion

This was a study comparing low profile dorsal plates with volar plates. Both dorsal and volar plating are effective methods in restoring anatomical reduction till union for fractures of all types and age groups, including patients with concomitant osteoporosis. Open reduction and internal fixation has 89–96% good to excellent results for anatomical restoration of distal radius fracture.

The open reduction and internal fixation with dorsal plating has good/excellent radiographic and functional outcome with minimal complications. Results with dorsal plating are comparable to open reduction and internal fixation with volar plating. Therefore dorsal plating can be used as an alternative method when dorsal buttressing of comminuted fracture is required, especially if bone is weakened with osteoporosis.

Ethical statement

This study was approved by the clinical audit department of the trust as part of clinical governance following a peer review process. Any data has been anonymised and has no patient identifiers. According to the Clinical Governance Arrangements for Research Ethics Committees this study does not require IRB review.

Conflicts of interest

The authors have none to declare.

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References

- Colles A. On the fracture of the carpal extremity of the radius. *Edinburgh Med Surg.* 1814;10:182–186.
- Nijs S, Broos PLO. Fractures of the distal radius: a contemporary approach. *Acta Chir Belg.* 2004;104:401–412.
- Herron M, Faraj A, Craigen MA. Dorsal plating for displaced intra-articular fractures of the distal radius. *Injury.* 2003;34(July (7)):497–502.
- Rausch S, Schlonski O, Klos K, et al. Volar versus dorsal latest-generation variable-angle locking plates for the fixation of AO type 23 C 2.1 distal radius fractures: a biomechanical study in cadavers. *Injury.* 2012. <http://dx.doi.org/10.1016/j.injury.2012.08.048>. pii:S0020-1383(12)00359-2.
- Yu YR, Makhni MC, Tabrizi S, Rozental TD, Mundanthanam G, Day CS. Complications of low-profile dorsal versus volar locking plates in the distal radius: a comparative study. *J Hand Surg Am.* 2011;36(July (7)):1135–1141.
- Zettl RP, Clauberg E, Nast-Kolb D, Ruchholtz S, Kühne CA. [Volar locking compression plating versus dorsal plating for fractures of the distal radius: a prospective, randomized study]. *Unfallchirurg.* 2009;112(August (8)):712–718.
- Rein S, Schikore H, Schneiders W, Amlang M, Zwipp H. Results of dorsal or volar plate fixation of AO type C3 distal radius fractures: a retrospective study. *J Hand Surg Am.* 2007;32(September (7)):954–961.
- Kamath AF, Zurakowski D, Day CS. Low-profile dorsal plating for dorsally angulated distal radius fractures: an outcomes study. *J Hand Surg Am.* 2006;31(September (7)):1061–1067.
- Ruch DS, Papadonikolakis A. Volar versus dorsal plating in the management of intra-articular distal radius fractures. *J Hand Surg Am.* 2006;31(January (1)):9–16.
- Sarmiento A, Pratt GAW, Berry NC, Sinclair WF. Colles' fractures: functional bracing in supination. *J Bone Jt Surg.* 1975;57A:311–317.
- Amadio PC, Berquist TH, Smith DK, Ilstrup DM, Cooney 3rd WP, Linscheid RL. Scaphoid malunion. *J Hand Surg Am.* 1989;14(July (4)):679–687.
- MacDermid JC, Roth JH, Richards RS. Pain and disability reported in the year following a distal radius fracture: a cohort study. *BMC Musculoskeletal Disorders.* 2003;4:24. <http://dx.doi.org/10.1186/1471-2474-4-24>.
- Ng CY, McQueen MM. What are the radiological predictors of functional outcome following fractures of the distal radius? *J Bone Joint Surg Br.* 2011;93-B(February):145–150.
- Campbell DA. Open reduction and internal fixation of intraarticular and unstable fractures of the distal radius using the AO distal radius plate. *J Hand Surg.* 2000;25B:528–534.
- Ring D, Jupiter JB, Brennwald J, et al. Prospective multicenter trial of a plate for dorsal fixation of distal radius fractures. *J Hand Surg Am.* 1997;22:777–784.
- Rozental TD, Beredjiklian PK, Bozentka DJ. Functional outcome and complications following two types of dorsal plating for unstable fractures of the distal part of the radius. *J Bone Jt Surg Am.* 2003;85:1956–1960.
- Wei J, Yang T-B, Luo W, Qin J-B, Kong F-J. Complications following dorsal versus volar plate fixation of distal radius fracture: a meta-analysis. *J Int Med Res.* 2013;41(April (2)):265–275.
- Lowry KJ, Gainor BJ, Hoskins JS. Extensor tendon rupture secondary to the AO/ASIF titanium distal radius plate without associated plate failure: a case report. *Am J Orthop.* 2000;29:789–791.
- Chung KC, Watt AJ, Kotsis SV, et al. Treatment of unstable distal radial fractures with the volar locking plating system. *J Bone Jt Surg Am.* 2006;88:2687–2690.