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Functional & Radiological Outcome of the Volar Locking Plate Fixation for Fracture of the Distal End Radius

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Abstract
Introduction: *Fractures of the lower end of the radius are most common fractures of the upper extremity, encountered in practice and constitute 17 % of all fractures and 75% of all forearm fractures. Distal radius fractures that are caused by severe high-energy trauma, results in intra-articular involvement and comminution. The aim of this study to determine the radiological & functional outcome of distal end of the radius fracture treated by volar locking plate.*
Methodology: *A prospective study of the fractures of the distal end of the radius, attending the Orthopaedics outdoor and the emergency services of Sardar Patel Medical College & Associated group of Hospital, Bikaner, between July 2015 to September 2016. 25 cases were followed up at regular intervals and final assessment was done at 3 months.*
Results: *Analysis of this study by according to GARTLAND & WERLEY Criteria and demerit criteria modified by Sarmiento, at 6 week the functional outcome showed mean value of affected limb such as residual deformity, subjective evaluation, objective evaluation, complications and ERPR were 1.24±1.26, 3.12±1.42, 3.4±3.5, 0.4±0.5 & 8.08±4.90 respectively and at 12 week were 0.92±0.95, 1.28±1.27, 1.48±2.28, 0±0 & 3.68±3.497 respectively.*
Conclusion: *It is concluded that 93% anatomical and 90% functional, excellent to good results, suggests that stabilizing the fracture fragments with volar plate and screws in the management of the fractures of distal radius, is an effective method to maintain the reduction till union and prevent collapse of the fracture fragments, even when the fracture is grossly comminuted/intra-articular/unstable and/or the bone is osteoporosed.*
Keywords: *Volar locking Plate, Fracture, Functional Outcome, radiological outcome.*

Introduction

Fractures of the lower end of the radius are most common fractures of the upper extremity, encountered in practice and constitute 17 % of all fractures and 75% of all forearm fractures[1]. Fracture of the distal radius continues to be one of the most common skeletal injuries treated by Orthopaedic or trauma surgeons. For many patients such as labourers, musicians, carpenters, surgeons and a dentist, loss of hand function means loss of a career.[2]

There appears to be a bimodal age distribution of distal radius fractures consisting of a younger group who sustains relatively high-energy trauma to the upper extremity and an elderly group who sustains both high-energy injuries and insufficiency fractures.[3] As life expectancy increase, the incidence of distal radial fractures can be expected to increase as well. Distal radius fracture is also frequently associated with low bone mineral density.

Distal radius fractures that are caused by severe high energy trauma, results in intra-articular involvement and comminution. These fractures often are unstable, are difficult to reduce anatomically, and are associated with a high rate of complication. Restoration of normal alignment and articular congruity after a displaced fracture can be difficult but it is essential for a good functional result. The residual deformity of wrist adversely affects wrist motion and hand function by interfering with the mechanical advantage of the extrinsic hand musculature[4]. It may cause pain, limitation of forearm motion, and decreased grip strength as a result of arthrosis of the radiocarpal and distal radioulnar joints[5].

Treatment of distal radius fracture is controversial; there is no single definitive treatment method that is considered the standard of care. Close reduction and cast immobilization has been the mainstay of treatment of these fractures but malunion of fracture and subluxation /dislocation of distal radioulnar joint resulting in poor functional and cosmetic results is the usual outcome[6]. It is important today to determine the nature of the fracture and to describe the bio-mechanism involved than to link diagnosis and treatment. The principles of treatment for distal radius fracture are the same as those for any other articular or periarticular fracture: anatomic reconstruction, stable fixation, and early motion.

The indications of use of volar locking plates are include the volar articular shear fracture— the eponymous "volar Barton" fracture, and the volarly displaced extra-articular fracture or "Smith fracture."

Material & Methods

A prospective study on cases of the fractures of the distal end of the radius, attending the Orthopaedics outdoor and the emergency services of Sardar Patel Medical College & Associated group of Hospital, Bikaner, between July 2015 to September 2016.

The fractures were classified according to Modified AO Classification. 25 cases were followed at regular intervals and final assessment was done at 3 months (photographic plate 2). This study was conducted with detailed clinical and radiological analysis after surgical management of fractures of distal end of radius.

Inclusion Criteria

1) Adult between age groups of 20 to 60 years with fracture lower end of radius
2) All patients having isolated fracture distal end of radius.

Exclusion Criteria

1. Open fracture
2. Pathological fracture
3. Distal radius fracture associated with other injury around the wrist joint
4. Patients with comorbid conditions preventing surgical intervention
5. Patients with more than 3 weeks duration of injury
6. Patients with local tissue condition making the surgery inadvisable

Preoperative Evaluation

All the patients were subjected to clinical examination. Radiographic evaluation of affected

& normal side was done at the time of injury with the anterio-posterior and lateral views (photographic plate 1). The radiographs were assessed in terms of loss of palmar tilt or presence of dorsal tilt, radial shortening and loss of radial inclination. Fractures were classified according to the AO Classification into type A (extra-articular), type B (partial articular) or type C (complete articular).

Surgical Procedure

The skin was incised longitudinally along the course of the flexor carpi radialis (FCR) tendon. The FCR tendon was retracted to the radial side to expose the ulnar corner of the distal radius. Underneath the FCR the flexor pollicis longus (FPL) is tendon were retracted ulnarly to reveal the pronator quadratus (PQ) muscle. The pronator quadratus muscle was elevated from its radial origin and reflected ulnarly to expose the distal radius.

Open reduction was performed with the aid of intrafocal leverage, traction by an assistant/ distractor, and provisional fixation by temporary Kirschner wires followed by definitive volar buttress or locking plate and screws. Image intensifier was used in theatre to assist the evaluation of fracture reduction and fixation.

After reduction and plate fixation layer by layer closure were done with the help of suture material. Aseptic dressing and above elbow slab was applied. Active finger and shoulder exercises were started at the earliest possible.

The plaster slab was removed after 2 weeks followed by a removable splint for 4 weeks. Patient was encouraged to remove the splint regularly and mobilise wrist.

Results

Our results showed the maximum male & female (n=9, n=5 respectively) were seen in 31-50 years of age group (group 1) and maximum cases (n=14) seen in 31-50 years of age, out of 25 operative cases 16 were right side and 8 were left side (table 2).

The mean value of radial deviation was 17.12 ± 4.4^0, radial length was 10.52±2.064 mm and volar tilt was 11.60 ± 6.654^0 in normal limb after procedure. Radial deviation was 16.32 ± 6.9^0, radial length was 11.12±3.75 mm and volar tilt was 1.880 ± 6.287^0 in affected limb after procedure (table 3).

In this study at 6 week the range of motion in mean value of affected limb such as dorsiflexon, palmarflexion, radial deviation, ulnar deviation, supination & pronation were 28.84±13.27, 33.20±12.30, 12.0±3.93, 12.28±4.614, 41.0±10.24 & 38.0±9.20 respectively and at 12 week were 63.12±23.0, 67.12±13.97, 18.24±3.179, 63.64±13.42 & 62.32±13.81 respectively. The difference between these two means percentage of movement statistical differ highly significant i.e. P<0.0001 (HS) in dorsiflexon, palmarflexion, radial deviation, ulnar deviation, supination & pronation (table 4). The mean value of functional outcome at different interval in table no. 5.

In this study according to GARTLAND & WERLEY Criteria result obtained at 6 week were 2 patients (8%) in excellent followed by 15 patients (60%) was in good outcome while 8 patients (32%) was in fair group. At 12 week 16 patients (64%) had excellent result, 6 patients (24%) had good result and 3 patients (12%) had fair result (table 6).

Table no. 1: Distribution of Case According To Age & Sex

Age Group	Sex		Total
	Male	Female	
≤ 30 yrs	6	0	6
31-50 yrs	9	5	14
>50 yrs	2	3	5
Total	17	8	25

Table no. 2: Case Distribution According To Age & Side

Age Group	Right	Left	Total
≤ 30 yrs	4	2	6
31-50 yrs	8	6	14
>50 yrs	4	1	5
Total	16	9	25

Table no. 3: Mean ± SD of Initial And Postoperative Radiological Parameters In Normal And Affected Upper Limb

Parameters	Normal (Mean ± SD)	Affected (Mean ± SD)
Radial Deviation	17.12±4.4 (10^0-28^0)	16.32±6.9 (5^0-36^0)
Radial Length	10.52±2.064 (8-15mm)	11.12±3.75 (5-18mm)
Volar Tilt	11.60±6.654 (4^0-28^0)	1.880±6.287 (-8^0-16^0)

Table no. 4: Mean ± SD of Range of Motion of affected Upper Limb at Different Interval

Range of Motion	6 Week	12 Week	P-value	Significance
Dorsiflexon	28.84±13.27	63.12±23.0	<0.0001	HS
Palmarflexon	33.20±12.30	67.12±13.97	<0.0001	HS
Radial Deviation	12.0±3.93	18.24±3.179	<0.0001	HS
Ulnar deviation	12.28±4.614	21.24±6.25	<0.0001	HS
Supination	41.0±10.24	63.64±13.42	<0.0001	HS
Pronation	38.0±9.20	62.32±13.81	<0.0001	HS

Table no. 5: Mean ± SD of Functional Outcome of affected Upper Limb at Different Interval

Functional Outcome	6 Week	12 Week
Residual Deformity	1.24±1.26	0.92±0.95
Subjective evaluation	3.12±1.42	1.28±1.27
Objective Evaluation	3.4±3.5	1.48±2.28
Complications	0.4±0.5	0±0
End Results Point Range	8.08±4.90	3.68±3.497

Table no. 6: Functional Result According To GARTLAND & WERLEY Criteria

Outcome	6^{th} Week	12^{th} Week
Excellent	2 (8%)	16 (64%)
Good	15 (60%)	6 (24%)
Fair	8 (32%)	3 (12%)
Poor	0 (0%)	0 (0%)

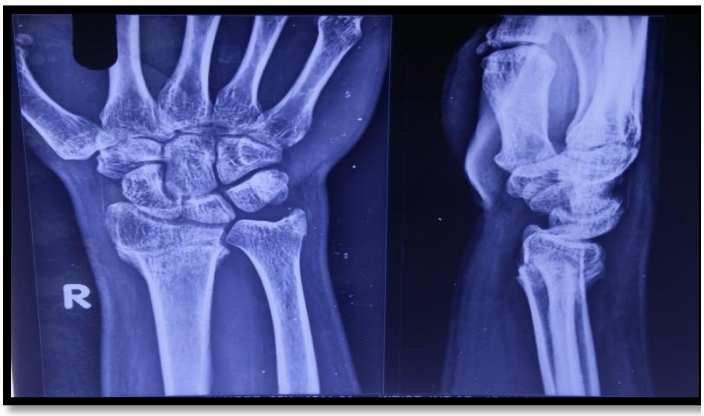

Photo plate 1: Fracture in distal side of radius in right side in X-rays

Photo plate 2: Placement of Volar Locking Plate in distal side of radius in right side in post-operative after 12 week.

Discussion

In our study results showed that Maximum male & female (n=9, n=5 respectively) were seen in 31-50 years of age group. For young, active patients, acceptable reduction is generally considered to be less than 10° dorsal tilt, less than 3 to 5 mm of radial shortening, and less than 2 mm of articular displacement.

Older patients have much weaker bones and can sustain a DRF from simply falling on an outstretched hand in a ground-level fall. An increasing awareness of osteoporosis has led to these injuries being termed fragility fractures, with the implication that a workup for osteoporosis should be a standard part of treatment. As the population lives longer, the frequency of this type of fracture will increase.

Kevin C. Chung et al (2008)[7] Fifty-five patients (30 young and 25 older adults) with unilateral, inadequately reduced DRFs were enrolled and received surgical treatment with the VLPS. At the 12 month assessment, older patients were able to achieve a higher mean MHQ score than their younger counter parts (normalized mean: 85% and 82%, respectively). This study indicate that the VLPS is successful in managing DRFs in older patients without increased complications compared to younger patients.

The present study shows that the maximum cases (n=14) seen in 31-50 years of age, out of 25 operative cases 16 were right side and 8 were left

side. This indicated that dominant hand was used first to touch the ground during accidental cases or fall on ground.

The present study to shows that mean value of radial deviation was 17.12±4.4^0, radial length was 10.52±2.064 mm and volar tilt was 11.60±6.654^0 in normal limb after procedure. Radial deviation was 16.32±6.9^0, radial length was 11.12±3.75 mm and volar tilt was 1.880±6.287^0 in affected limb after procedure. Three radiographic measurements are accepted in the anatomical evaluation of the distal end of the radius (Gartlend and Werley 1951[8], Lidstorm 1959[9], Scheck 1962[10], Cole & Obletz[11]). These parameters are measured to determine the degree of displacement and impaction. These are volar/dorsal tilt, radial deviation and radial lengths.

Tamara D. Rozental et al (2006)[12] studies 41 patients with a mean age of 53 years. The average follow-up period was 17 months. All fractures were stabilized with volar locking plates. Radiographs in the immediate postoperative period showed a mean radial height of 11mm, mean radial inclination of 21^0, and mean volar tilt of 4^0. At fracture healing the mean radial height was 11mm, mean radial inclination was 21^0 and mean volar tilt was 5^0.

The difference between these two means percentage of movement statistical differ highly significant i.e. P<0.0001 (HS) in dorsiflexon, palmarflexion, radial deviation, ulnar deviation, supination & pronation in present study.

Constantine et al[13] reported using a volar plate (π Plate; Synthes, Paoli, PA) in 20 dorsally displaced distal radius fractures with 12 months of follow-up evaluation. Eighty percent of the fractures were intraarticular and 80% of patients began active wrist range of motion at the first postoperative visit. The researchers reported no loss of reduction, an average flexion-extension arc of 123°, an average pronation, supination arc of 156°, and a low incidence of complications.

Orbay and Fernandez[14] described using a precontoured, fixed-angle volar plate and screw system for dorsally unstable distal radius fractures. They performed a prospective study of 31 fractures in 29 patients with 13 months of follow-up evaluation. They reported only 2 patients who had 1 mm of radial length loss. Motion was initiated at an average of 7 days, the final average flexion-extension arc was 112°, and the final average pronation-supination arc was 158°.

The functional outcome in this study the mean value of affected limb such as residual deformity, subjective evaluation, objective evaluation, complications and ERPR were 1.24±1.26, 3.12±1.42, 3.4±3.5, 0.4±0.5 & 8.08±4.90 respectively and at 12 week were 0.92±0.95, 1.28±1.27, 1.48±2.28, 0±0 & 3.68±3.497 respectively. Several studies have suggested that restoration of the articular anatomy is the most critical factor in obtaining a good functional result and preventing late post traumatic arthritis. Before the incision is made, distraction and the temporary application of an external fixator will make it easier to manipulate the small articular fragments and minimize soft tissue dissection. The anterior approach is useful for fractures with anterior displacement or rotation of the articular fragments.

Function is difficult to define and even more difficult to quantify. The functional end result can be judged with certainty only after one year of the injury. We used Gartland & Werley 1951[15] demerit criteria modified by Sarmiento et al 1975[16]. In this system subjective, objective and radiological findings are taken into considerations. Subjective evaluation includes pain, disability, limitation of movement, restriction of activities.

According to GARTLAND & WERLEY Criteria result obtained at 6 week were 2 patients (8%) in excellent followed by 15 patients (60%) was in good outcome while 8 patients (32%) was in fair group. At 12 week 16 patients (64%) had excellent result, 6 patients (24%) had good result and 3 patients (12%) had fair result in our study. More recent work has suggested that outcomes may be more dependent on patient factors, with

elderly patients of lower functional demand more tolerant of persistent radiographic abnormalities

This is an important part of fractures management (Golden 1963[17], Bohler 1929[18]), stressed the value of active functional training. To ensure best functions results therapy should be done by patient himself under proper medical supervision (Frykman 1967[19], Collins 1993[20]). Therapy includes measures to reduce edema, maintain range of motion of uninvolved joints mobilise soft tissue structures; assist in pain management, monitoring for compression of nerves (Collins 1993)[20].

Conclusion

The present study concluded that 93% anatomical and 90% functional, excellent to good results, suggests that stabilizing the fracture fragments with volar plate and screws in the management of the fractures of distal radius, is an effective method to maintain the reduction till union and prevent collapse of the fracture fragments, even when the fracture is grossly comminuted/intra-articular/unstable and/or the bone is osteoporosed.

The technique emphasises that open reduction and internal fixation with volar plating has excellent functional outcome with minimal complications thus proving that it is the prime modality of treatment for distal radius fractures. Given the apparent success of volar plate fixation of dorsally unstable distal radius fractures further investigation is warranted into implant design, the indication for supplementary fixation, and range-of-motion protocols.

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