International Journal of Research in Orthopaedics
Prakash V et al. Int J Res Orthop. 2023 May;9(3):506-512
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20231051

Outcome of treatment of intra-articular distal end radius fractures by volar locking plate versus bridging external fixator augmented by single K-wire through radial styloid

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Received: 22 March 2023
Revised: 04 April 2023
Accepted: 07 April 2023

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ABSTRACT

Background: Distal radius fractures are common injuries occurring more frequently than any other fracture, and remain one of the most frequent skeletal injuries treated by orthopaedic or trauma surgeons. They are considered the most common fracture of the upper extremity.
The use of percutaneous pin fixation, external fixation devices that permit distraction and palmar translation, low-profile internal fixation plates and implants, arthroscopically assisted reduction, and grafting techniques including bone-graft substitutes all have contributed to improving fracture stability and outcome.
Methods: This is a prospective study consisting of 30 patients, who were treated with volar locking plate or K-wire augmented external fixation for intra-articular commented distal radius fractures (AO type C) at Rajendra institute of medical sciences between November 2020 and January 2023. The 15 patients were treated with open reduction using the volar approach and locking plate were used while 15 patients were treated with closed reduction under fluoroscopy, distraction with the external fixator (Joshi type external fixator) along with K-wire fixation for additional stability used.
Result: The ORIF with plating group showed better functional outcomes in Green and O'Brien compared to ex fix group. The radiographic results in the ORIF group were more favorable than in the EF group.
Conclusions: We found that both ORIF with plating and external fixation represent treatment choices for distal radius fractures. ORIF had better functional and radiological outcomes according to Green and O'Brien and Sarmiento scoring systems when compared to external fixation. ORIF had less incidence of complications compared with external fixation.

Keywords: Ligamentotaxis, Volar locking plate, Green and O' Brien score, Sarmiento radiological score

INTRODUCTION

Distal radius fractures are common injuries occurring more frequently than any other fracture, and remain one of the most frequent skeletal injuries treated by orthopedic or trauma surgons.[1-3] They are considered the most common fracture of the upper extremity.[4,5]

The articular surface of the radius is triangular, with the apex of the triangle at the radial styloid. It slopes in a volar and ulnar direction with a radial inclination of 23° (range 13-30°), a radial length of 12 mm (range 8-18 mm), and an average volar tilt of 12° (1-21°).[6] Anderson and O Neil were first to maintain fracture reduction with an external fixator using the principle of ligamentotaxis.

Treatments vary from simple splinting to surgical reduction[7] with combined internal and external fixation.[8]

Restoration of normal alignment and articular congruity after a displaced fracture can be difficult but is essential for a good functional result.[9,10]

The use of percutancous pin fixation, external fixation devices that permit distraction and palmar translation, low-profile internal fixation plates and implants, arthroscopically assisted reduction, and grafting techniques including bone-graft substitutes all have contributed to improving fracture stability and outcome.[11] External fixation, currently widely used to treat these fractures, is minimally invasive. It uses traction to maintain fracture-fragment reduction so that additional trauma from dissection of the soft tissues around the fracture during open reduction and plate fixation is avoided.[12,13] However Many authors have reported significant losses of reduction, from pin loosening, infection and fixation failure.[14-17] The stability of distal radius fracture fixation may be more dependent on the means to augment fixation than on the strength of an external fixator itself.[18] The external fixation effectively can not protect comminuted distal-radius fractures from loss of the reduction originally attained; severe comminution is often associated with shortening and redisplacement.[19] The immediate improvement in radial height, inclination, and volar tilt are significantly decreased by the time of fixator removal.[20]

Traction does not correct the dorsal tilt of the distal fracture fragment. This is because the stout volar radiocarpal ligaments are shorter, and they pull out to length before the thinner dorsal radiocarpal ligaments exert any traction.[21] Excessive tractions can actually increase the dorsal tilt.[22] A dorsally directed vector is still necessary to restore the normal volar angulation.

This is usually accomplished by applying manual thumb pressure over the dorsum of the distal fragment. With intra-articular fractures, ligamentotaxis reduces the radial styloid fragment, but for the above reasons, it does not reduce a depressed lunate fragment.[23]

Distraction also increases the carpal canal pressure, which may predispose to acute carpal tunnel syndrome.[24]

Many authors have stressed the importance of using the external fixator as neutralization device rather than as a traction device. Ligamentotaxis is used to obtain a reduction of the fracture fragments, which is then captured with percutaneous K-wire fixation. The traction on the fixator can then be reduced, which allows positioning of the wrist in neutral or slight extension.[25] This serves to reduce extensor tendon tightness and facilitates finger motion.

The efficacy of ligamentotaxis in neutralizing detrimental compression forces, which are likely to cause displacement of unstable fracture with radial shortening, is a significant and increasingly appealing advance in the management of distal radius fractures.[26]

Contraindications of bridging external fixation are:Ulnar translocation due to an unstable distal radioulnar joint; Intra-articular volar shear fractures (Bartons, reverse Bartons); Disrupted volar carpal ligaments/radiocarpal dislocations; Index finger metacarpal fractures preclude the use of this technique due to the interference with distal pin site placement.

Modified Henry approach to the radius for volar plating: It is suitable for most distal radial fractures. This approach utilizes the plane between flexor carpi radialis (FCR) tendon and the radial artery, i.e., ulnar to the radial artery. The classical Henry approach uses the plane between brachioradialis and the radial artery, i.e., radial to the radial artery. During modified Henry approach, radial artery and the palmar branch of the median nerve are at risk of injury.

Objective of study is to assess the functional and radiological outcomes according to Green and O'Brien and Sarmiento scoring systems and compare them in ORIF and plating group vs external fixation group and also compare the incidence of complications in each group. Post-op ranges of motion, grip strength were also compared.

METHODS

This is a prospective study consisting of 30 patients, who were treated with volar locking plate or K-wire augmented external fixation for intra-articular comminuted distal radius fractures (AO type C) at Rajendra institute of medical sciences between November 2020 and January 2023.

The 15 patients were treated with open reduction using the volar approach and locking plate were used while 15 patients were treated with closed reduction under fluoroscopy, distraction with the external fixator (Joshi type external fixator) along with K-wire fixation for additional stability were used.

Inclusion criteria

Patients aged 18-60 years with recent intra-articular fracture of the distal radius with no medical contraindications for anesthesia were included and Fracture less than 2 weeks old were included.

Exclusion criteria

Patients with distal radius fracture treated with closed reduction and cast immobilisation; patient with additional injuries like head injuries, open fractures of distal radius, fracture older than 14 days, active infection or severe radiocarpal arthritis, pathological fractures, fracture with neurovascular complications were excluded.

Henry approach was used for the volar locking plate.[27-29] In the external fixation group, distraction with the Joshi type external fixator was performed following closed reduction under fluoroscopy. A simple method to determine the upper limit of distraction during surgery by the observation that all fingers, in particular the second finger, can touch the palm of the hand with passive flexion (second finger reaching the distal palmar flexor fold with passive flexion).

For additional stability, the fragments were reduced and fixed with 1.5 to 2 mm K-wires. Single K-wire was inserted through radial styloid.

Following surgery, a POP cast was applied in the volar locking plate group, that did not go beyond the metacarpophalangeal joint and reached the bottom of the elbow. Active finger exercises were started the day after surgery. POP cast was removed at 4th week and wrist brace was prescribed. At the end of eight weeks, an exercise program for muscle strengthening was started depending on the level of union.

In the external fixation group, finger movements were started the day after surgery. K-wires used for augmentation were pulled out between week 4 and week 6. The external fixator was removed under sedation between 5 to 12 weeks and rehabilitation with active and passive exercises were started with the support of a wrist brace. By the end of 12 weeks, muscle strengthening exercises were started depending on the level of union.

For functional assessment, range of motion of wrist joint was measured with a goniometer. Grip strength was measured using a dynamometer and compared with the healthy side.

By comparison of radiographic measurements, losses in palmar angulation, radial length, and radial inclination, and ulnar variance were determined for patients.[30] For both the groups follow-up period was 12 months.

Fracture was classified according to AO classification.[31]

Ethical approval done.

Statistical tool

Excel software and Microsoft words were used to analyse the data. Percentage was calculated for qualitative data.

RESULTS

The fractures were on the right side in 17 patients, and on the left in 13 patients. Etiologies were fall (n=15), fall from height (n=9), and traffic accidents (n=6).

The 15 patients were managed by ORIF with plating and 15 patients were managed by external fixator. In all patients of ORIF group, the amount of blood loss was less than 500 ml. The mean operation time was 45 minutes in the ORIF group, in comparison to 25 minutes in the Ex fix group.

Table 1: Age distribution.

Age (years)	N
18-20	4
21-40	9
41-60	17

Table 2: Sex incidence.

Sex	N
Male	20
Female	10

Table 3: Outcomes according to Green and O' Brien score.

Variables	Plating group	Ex fix group
Score		
ROM	25	20
Pain	25	25
Grip strength	25	25
Activity	25	25
Classification, N (%)		
Poor	0	1 (6.6)
Fair	1 (6.6)	2 (13.3)
Good	3 (20)	1 (6.6)
Excellent	11 (73.3)	11 (73.3)

Table 4: Outcome according to Sarmiento radiological score.

Variables	Plating group	Ex fix group
Palmer tilt	4.5	5.5
Radial height	10	11.5
Radial inclination	19.5	21
Classification, N (%)		
Fair	1 (6.6)	2 (13.3)
Good	1 (6.6)	2 (13.3)
Excellent	13 (86.6)	11 (73.3)

Table 5: Complications.

Variables	ORIF, n (%)	Ex fix, n (%)
Nerve injury	0	0
Stiffness	2 (13.3)	3 (20)
Malunion	1 (6.6)	3 (20)
Complex regional pain syndrome	0	2 (13.3)
Pin tract infection	0	1 (6.6)

The ORIF with plating group showed better functional outcomes in Green and O'Brien compared to Ex fix group. The 93.3% of the ORIF group had accepted functional outcomes (73.3% excellent, 20% good), while 79.9% of

the ex-fix group had accepted functional outcomes (73.3% excellent, 6.6% good). The radiographic results in the ORIF group were more favourable than in the EF group, where 93.2% of the ORIF group had acceptable radiological parameters (86.6% got excellent in Sarmiento score), the percentage was 86.6% in the ex-fix group (73.3% got excellent and 13.3% got good in Sarmiento score).

The radiographic results in the ORIF with plating group were more favorable than in the external fixator group. The percentage of patients with acceptable volar tilt, radial length and radial inclination in the ORIF group was 93.2%, while in the external fixator group it was 86.6%. This is mostly because of plating which allows direct visualization and manipulation of the fracture and therefore provides better restoration of radial height, radial inclination, volar tilt and articular congruity.

In the current study, ORIF had an overall decreased incidence of complications compared with external fixation, Complex regional pain syndrome was observed in 2 patients (13.3%) in the EF group but was not encountered in ORIF group. This may be related to the severity of injury or excessive distraction and reduction manoeuvres associated with external fixation. This can be avoided by early wrist rehabilitation, avoidance of over distraction during external fixator application and postoperative vitamin C supplementation.

Stiffness was observed in 2 patients (13.3%) of the ORIF group, in comparison to 3 patients (20%) in the EF group.

In the ORIF group, the strength and stability of the construct allows early wrist motion, and this has been shown to decrease the incidence of stiffness and enhance hand and finger function. Infection was observed only in 1 patient (6.6%) of the external fixator group (pin tract infection) but was absent in ORIF group. Malunion was observed in 3 patients (20%) of the extermal fixation group compared to only 1patient (6.6%) in the ORIF group. In this study, ORIF restored volar tilt and radial inclination better than external fixation.

Figure 1: Case 1 (Pre op X-ray of fracture distal end radius).

Figure 2: Case 1 (post op X-ray showing volar plating).

Figure 3: Case 2 (pre op X-ray).

Figure 4: Case 2 (post op X-ray with plating).

Figure 5: Case 3 (pre op X-ray).

Figure 6: Case 3 (post op X-ray radial distractor fixed. Single K- wire was inserted through radial styloid).

Figure 7: Case 4 (pre op X-ray).

Figure 8: Case 4 (Radial distractor with single k wire through radial styloid with principle of ligamentotaxis working).

Figure 9: Case 5 (pre op X-ray).

Figure 10: Case 5 with post op X-ray

DISCUSSION

Goals of treatment are: restoring the joint surface to protect the joint cartilage, achieving radial alignment and height to preserve normal kinematics of the joint, providing mobility for maintenance of finger-wrist and forearm functions, and ensuring stability to protect length-alignment-joint surface congruency until recovery.[32]

Functional assessment showed that wrist flexion and supination were better with palmar plate; however, the two groups were similar with respect to grip strength loss and time to return to work.

Westphal and colleagues performed a retrospective comparative study of 166 of 237 patients who had surgery for AQ/ASIF A3 or C2 distal radius fractures. The fractures were treated with either external fixation or open reduction and internal fixation using palmar or dorsal plates. Open reduction and internal fixation, in particular palmar plate fixation, demonstrated the best radiological and functional results.[33]

Radiographically, it was shown that palmar plating was associated with better correction of palmar angulation and protection of ulnar variance. This may be explained by the fact that distraction primarily occurs via palmar structures and that palmar locking plate provides a better support to the fracture. Traction alone in external fixation cannot correct palmar angulation due to the fact that ligamentotaxis primarily functions through strong palmar links.[27-30,34]

As external fixation cannot fix a fracture as stable as seen by a locking plate and needs to be removed after a while, it cannot provide a firm basis against compression in the fracture.

In external fixation applications, losses in palmar angulation may continue in the long term (even after the removal of the fixation).[35] On the other hand, palmar angulation can be better corrected because of direct intervention provided by open reduction and palmar plate

fixation. While the subchondral distal screws of the palmar locking plate provide support against palmar angulation losses, they also prevent compression of the fracture in the long term.[27] The superior mobility achieved with the palmar locking plate may be attributed to the fact that these patients can start wrist movements earlier owing to firm fixation. All external fixators used in our study went beyond the joint and were not dynamized. Thus, mobility of the wrist joint was not allowed until the fixator was removed. This may explain mobility losses in the external fixation group.

Despite its advantages, there are still fracture types where volar locking plate cannot be applied. Especially in comminuted very distal fractures that do not allow screw insertion, K-wire augmented external fixation may yield successful results.

When Seitz and colleagues investigated the technique of "augmentation" of external fixation, in which percutaneous Kirschner wires are used as a lateral buttress to secure the radial stvloid fragment, their reported rate of result that were satisfactory overall was 92%.[36]

The ORIF with plating group showed better functional outcomes in Green and O'Brien compared to ex fix group. The 93.3% of ORIF group had accepted functional outcomes (73.3% excellent, 20% good), while 79.9% of the Ex fix group had accepted functional outcomes (73.3% excellent, 6.6% good). Most of the prior studies are in agreement with these results as in Williksen et al, Abramo et al, Rozental et al, Wei et al and Egol et al.[37-41]

Recent biomechanical and clinical studies which were undertaken for knowing the distal radius fixation revealed placement of locking screws in the metaphyseal bone with as close as 5mm close to the distal subchondral bone without violating its articular surface.[42]

It became evident that more screw placement in the distal metaphyseal acts as reefing technique.

Limitation

Limitation of study are small number of patients in each treatment group, a short follow-up period and a failure to measure inter-observer errors in radiographic interpretation or functional evaluation.

CONCLUSION

From our study, we conclude that patients with unstable, either a dorsally or volarly displaced intraarticular radius fracture or type C (Complete intraarticular fractures) or in osteoporotic fractures had excellent to good radiological outcome when treated with fixed angle volar locking plate because it maintains the reduction till union and prevent the collapse of the fracture fragments. ORIF had better functional and radiological outcomes according to Green & O'Brien and Sarmiento scoring systems when compared to external fixation. ORIF had less incidence of complications compared with external fixation. ORIF allows for early postoperative range of motion exercises as compared to external fixation. The grip strength was better in the ORIF group; however, it improved gradually in external fixation group after frame removal and physiotherapy, thus became comparable to the ORIF group. External fixation is a rapid and minimally-invasive method with comparable functional outcome with other methods of fixation.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Prakash V, Singh N, Prabhat V. Outcome of treatment of intra-articular distal end radius fractures by volar locking plate versus bridging external fixator augmented by single K-wire through radial styloid. Int J Res Orthop 2023;9:506-12.