OUTCOME OF DISTAL RADIUS MALUNIONS MANAGED BY CORRECTIVE OSTEOTOMY BY VOLAR APPROACH- A CLINICAL AND RADIOLOGICAL STUDY

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ABSTRACT

BACKGROUND

Malunion is the most common complication following distal radius fractures with a greater prevalence among lower socioeconomic status in Indian subcontinent. Pain at the wrist, decreased grip strength and decreased range of movements at the joint are the usual presenting symptoms. Malunion leads to functional limitation of affected wrist significantly hampering the activities of daily living and loss of employment. It can be treated by surgical intervention. We report the functional and radiological outcome after corrective osteotomy of malunited distal radius using volar approach and fixation with a volar locked plate.

MATERIALS AND METHODS

16 malunited distal radius fractures in skeletally-matured patients were treated with an osteotomy and iliac crest corticocancellous bone graft. Corrective osteotomy with definitive fixation was done using a distal radius volar plate osteosynthesis. Outcomes were evaluated using modified Mayo wrist score and DASH questionnaire.

RESULTS

On radiological evaluation post operatively, radial inclination was in the range of 20.9 degrees, a volar inclination of 7.9 degrees. All osteotomies healed within acceptable limit by modified Graham's radiographic criteria of acceptable healing of distal radius fractures. Modified Mayo wrist score assessment shows 4 excellent results, 8 having good results, 4 having satisfactory results and no poor results. The average score is 82.5 (range 65-90). DASH questionnaire. Analysis postoperatively revealed the average score is improved from preoperative mean 60.36 to 18.49.

CONCLUSION

Corrective osteotomy and volar plate fixation of distal radius for symptomatic malunion gives favourable radiological and functional outcome with improvements in grip strength, range of movements, pain and cosmesis.

KEYWORDS

Distal Radius, Malunion, Volar Plating, Corrective Osteotomy.

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BACKGROUND

Wrist joint is the key mediator between hand and rest of the upper limb offering both stability and mobility in equal parts with multiaxial and multiplanar motion. It is a complex saddle type of joint with radius being major load transmitter in the wrist accounting for 80% of axial load transmission, while ulna carries 20%.[1,2] Distal radius has two major articulations with scaphoid and lunate bone and multiple ligamentous attachments. Distal radius fracture is a very common and often neglected ailment prevalent in Indian subpopulation. As per literature, malunion is the most common complication following distal radius fractures occurring approximately in 23% of non-surgically treated injuries and in 11% of operatively-treated fractures.[3,4,5] Common cause being fall on outstretched hand with a history of high velocity injuries among younger age group, while elderly age group, especially postmenopausal women sustain it due to trivial fall.[6] Conservative management of distal radius fractures by poor technique or by avoiding early consultation or by quacks applying native bandages is the usual cause of malunion in Indian subcontinent. Pain at the wrist, decreased grip strength and decreased range of movements at the joint are the usual presenting symptoms. Biomechanically, an increased contact pressure across the ulna is due to the loss of radial height, especially when the articular surface of the radius has dorsal angulations. The relationship that distal ulna has with the radius regulates the

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multiaxial and multiplanar mobility. Decreased radial length with distal migration of ulna causes an imbalance in axial load transmission with an increase in ulna's share up to 42% with additional impact from disrupted DRUJ and strained Triangular Fibrocartilage Complex (TFCC).[7] Various methods of corrective osteotomies have been proposed. Authors such as Fernandez have described the traditional treatment of osteotomy and dorsal plating with bone graft for dorsal angulated malunions.[8] These techniques guarantee good restoration of the anatomy and relieve pain, but have sometimes been associated with irritation or rupture of extensor tendons. Volar approach and corrective osteotomy is rapidly gaining popularity as it is associated with a smaller incision with an easier approach and fewer tendon problems.[9] In current study, we evaluate the clinical and functional outcome obtained by corrective osteotomy and definitive fixation through volar approach for distal radius malunions.

MATERIALS AND METHODS

This is a longitudinal prospective cohort study performed at our institute from December 2015 to August 2017. Ethical clearance was obtained at our institute. Our study included people with malunited distal radius fracture within the age group of 20 years to 65 years. The inclusion criteria were patients with malunited distal radius fracture (extra-articular or simple intra-articular fractures) following conservative management with pain, deformity, decreased range of mobility and decreased grip strength compared to the normal side clinically with radiologic parameters showing united fracture site with dorsal tilt of more than 15°, radial shortening greater than 5 mm, articular displacement of more than 2 mm at radiocarpal joint. Exclusion criteria included patients who did not give consent to the procedure, patients aged <20 years and >65 years, patients who had clinical and radiological signs of reflex sympathetic dystrophy, degenerative joint disease and complex multiplanar intra-articular malunions. Osteopenia and osteoporosis are a common association of malunited distal radius fractures and hence were not excluded. A total of 16 patients were included in our study. Their demographic and preoperative assessments are categorised in the following tables. Preoperative radiographs were taken using computerised radiography and following calculations were made- Radial height, radial inclination, volar or dorsal tilt and ulnar variance. All of them were documented and a print of the radiograph was taken and traced out on a tracing paper. Correction was planned using normal wrist as a control.

Sl. No.	Age	Sex	DI*	RI*	UV*	RL*	F/E*	S/P*	Pain*	Side*
1.	46 years	Male	20.30	18.07	Neutral	6.4 mm	60 (55/5)	70 (65/5)	7	Right
2.	45 years	Male	20.5	12.4	positive	6.6 mm	80 (40/40)	100 (60/40)	8	Right
3.	30 years	Male	24.4	10.7	Positive	5.7 mm	90 (30/60)	90 (20/70)	8	Left
4.	45 years	Female	20.6	7.9	Positive	3.6 mm	70 (30/40)	90 (60/30)	9	Right
5.	63 years	Male	28.1	13.2	Positive	5.2 mm	80 (30/50)	70 (40/30)	9	Left
6.	60 years	Male	21	8.91	Neutral	4.6 mm	60 (30/30)	110 (70/40)	9	Right
7.	50 years	Male	20.8	10.7	Positive	7.8 mm	90 (20/70)	130 (60/70)	7	Left
8.	65 years	Male	14	7.4	Positive	6.6 mm	110 (40/70)	60 (30/30)	8	Left
9.	40 years	Female	26.1	19.9	Positive	7 mm	70 (30/40)	30 (10/20)	9	Right
10.	45 years	Male	16.8	12.2	Positive	6.4 mm	80 (30/50)	40 (20/20)	8	Right
11.	27 years	Female	18.8	11.2	Positive	5.8 mm	90 (40/50)	60 (30/30)	7	Left
12.	42 years	Female	12.6	14.8	Neutral	7.4 mm	70 (50/20)	90 (30/60)	7	Right
13.	55 years	Male	20.1	8.4	Positive	5.6 mm	60 (50/10)	80 (20/60)	8	Right
14.	45 years	Male	12.6	11.2	Positive	6.2 mm	100 (40/60)	60 (20/40)	6	Right
15.	34 years	Male	14.4	8.8	Positive	6.1 mm	120 (40/80)	100 (40/60)	7	Right
16.	32 years	Male	11.8	12.6	Neutral	6.8 mm	110 (40/70)	130 (60/70)	7	Right

Table 1. Preop Clinical and Radiographic Assessment

(Abbreviation- DI*= Dorsal incination; RI*= Radial Inclination; UV*= Ulnar variance; RL*= Radial Length; F/E*= Flexion/Extension; S/P*= Supination/Pronation).

Figure 1. a) Pre-op Clinical Photos; b) Radiographs Showing Reduced Radial Length

Figure 2. a) Pre op Clinical Photos; b) Radiographs Showing Dorsal Inclination

Figure 3. a) Pre op Clinical Photos; b) Radiographs Showing Reduced Radial Length and Dorsal Inclination

In all the patients, a volar Henry's approach was used. A longitudinal incision was made just radial to flexor carpi radialis. Radial artery was identified and protected by retracting it radially under brachioradialis muscle. The pronator quadratus was incised as a single layer close to insertion. Malunion was exposed under direct vision and any signs of fracture line at the site inspected. If present, the line was used to make the osteotomy cut with the assistance of C-arm fluoroscopy. If absent, osteotomy cut was made 2 cm away from joint line. Leverage was applied with an osteotome and distraction was verified fluoroscopically. Once the satisfactory radiographic picture was obtained, corticocancellous wedge-shaped graft harvested from ipsilateral iliac bone was inserted and provisionally fixed with a thin 0.0625 inch K-wire passed through the radial styloid process across the fracture site in a diagonal manner, while maintaining a volar tilt to the wrist to obtain volar inclination. A volar distal radius "T-shaped Ellis plate" was applied after desired correction was obtained and fixed with screws. K-wire was removed or sometimes left along with the implant for 6 weeks. Wound was closed in standard fashion and a dorsal plaster splint was applied. Suture removal was done on 10-14 postop day and plaster splint was reapplied at the time of discharge for 2 weeks.

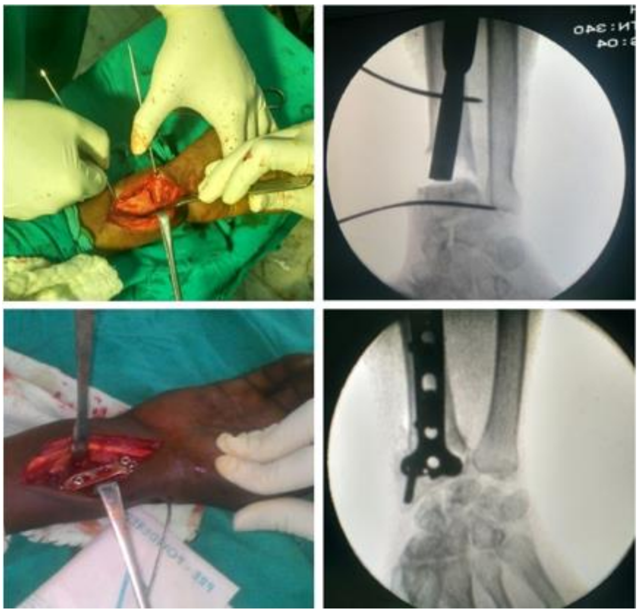


Figure 4. Intra op and Fluoroscopy Images of Corrective Osteotomy and Plate Osteosynthesis

Evaluation and Endpoints

We have clinically evaluated patients in our study postoperatively at 2 weeks, 6 weeks and 12 weeks. It is our routine practice to take radiographs at 6 weeks and 3 months. Patients underwent clinical evaluation postoperatively in terms of grip strength, range of movements and pain and improvement was noted in all patients. Some of them had a delayed examination if there was a K-wire left in place, which was removed at 6 weeks. Grip strength was measured using a dynamometer. Range of movements was measured using goniometer. Pain was assessed using visual analogue scale. Functional improvement was evaluated using modified Mayo wrist score, DASH score and radiographic improvement was evaluated using modified Graham's criteria.

All radiographic measurements were made using Picture Archiving and Communication Systems (PACS, Cyanomed technologies). Radiological criteria included bridging of the fracture site by bone, callus or trabeculae, bridging of the fracture seen at the cortices and obliteration of the fracture line or cortical continuity. Any complications like residual pain, tendon ruptures, etc. were noted.

RESULTS

All the 16 patients had relief of their symptoms in varying degrees. Mean average time from the initial date of injury to surgery was 10.8 weeks. Clinically, they had an improvement in pain, grip strength and range of motion.

Preoperative mean dorsi flexion of the wrist was 46.5 degrees, which improved postoperatively to 65 degrees. Preoperative mean palmar flexion improved from 35.95 degrees to 61.25 degrees. Similarly, preoperative pronation improved from 42.1 degrees to 63.1 degrees and supination improved from 39.6 degrees to 66.8 degrees. There was minimal improvement in terms of radial deviation of wrist, but ulnar deviation improved.

Radiologically, radial length improved from a mean of 6.1 mm preoperatively to a mean of 11.6 mm postoperatively. The mean dorsal inclination of 18.91 degrees has been restored postoperatively to a mean volar inclination of 7.9 degrees. Radial inclination improved from a mean of 11.7 degrees preoperatively to a mean of 20.9 degrees postoperatively. Ulnar variance decreased from a mean of +5.4 mm preoperatively to a value of +0.8 mm postoperatively.

Mayo wrist score was assessed for 16 patients. Of the 16 patients, 4 had excellent results with 8 had good results and 4 had satisfactory results. All patients had a decrease in DASH scale from a mean of 60.36 preoperatively to a value of 18.49 postoperatively.

Sl. No.	VI*	RI*	UV*	RL*	F/E*	S/P*	Pain	MMS* Preop vs. Postop		DASH* Preop vs. DASH* Postop	
1.	10.5	21.5	Neutral	12.8 mm	140 (90/50)	120 (90/30)	2	25	85	60.4	13.2
2.	12.15	26.9	Negative	13.2 mm	150 (70/80)	150 (90/60)	2	45	85	64.4	12.1
3.	6.6	19.2	Neutral	11 mm	130 (50/80)	140 (50/90)	1	30	85	58.4	14.6
4.	4.5	14.7	Neutral	7.3 mm	100 (30/70)	160 (90/70)	3	25	75	54.8	18.8
5.	8.7	21.4	Neutral	10.6 mm	130 (50/80)	130 (80/50)	2	25	85	64.2	16.8
6.	11	28.3	Neutral	14.6 mm	120 (70/50)	140 (90/60)	1	20	75	65.4	20.2
7.	3.5	24.6	Negative	13 mm	140 (60/80)	160 (90/70)	3	30	90	57.4	10.2
8.	4.5	19.5	Neutral	11.2 mm	130 (50/80)	130 (80/50)	2	30	85	60.8	18.2
9.	14.6	23.6	Positive	10.3 mm	90 (50/40)	110 (40/70)	1	25	70	56.2	21.8
10.	5.8	18.8	Neutral	10.8 mm	120 (80/40)	100 (50/50)	3	25	80	58.4	20.2
11.	4.8	16.4	Neutral	11.3 mm	140 (60/80)	90 (40/50)	3	35	90	60.4	16.6
12.	7.8	21.8	Neutral	10.8 mm	110 (70/50)	120 (50/70)	2	30	80	55.6	20.8
13.	11.8	22.2	Negative	12.6 mm	100 (70/30)	110 (40/70)	3	20	70	62.2	24.6
14.	7.4	18.2	Neutral	13.8 mm	140 (60/80)	140 (60/70)	2	35	85	60.8	22.2
15.	5.4	19.4	Neutral	10.8	120 (60/60)	130 (70/60)	1	20	90	68.8	27.8
16.	8.8	18.2	Neutral	12.2	140 (60/80)	150 (60/90)	2	40	90	57.6	17.8

Table 2. Postoperative Clinical and Radiographic Assessment

(Abbrevation- VI*= Volar incination; RI*= Radial Inclination; UV*= Ulnar variance; RL*= Radial Length; F/E*= Flexion/Extension; S/P*= Supination/Pronation; MMS*= Modified Mayo Wrist Score; DASH*= Disabilities of arm, shoulder and hand).

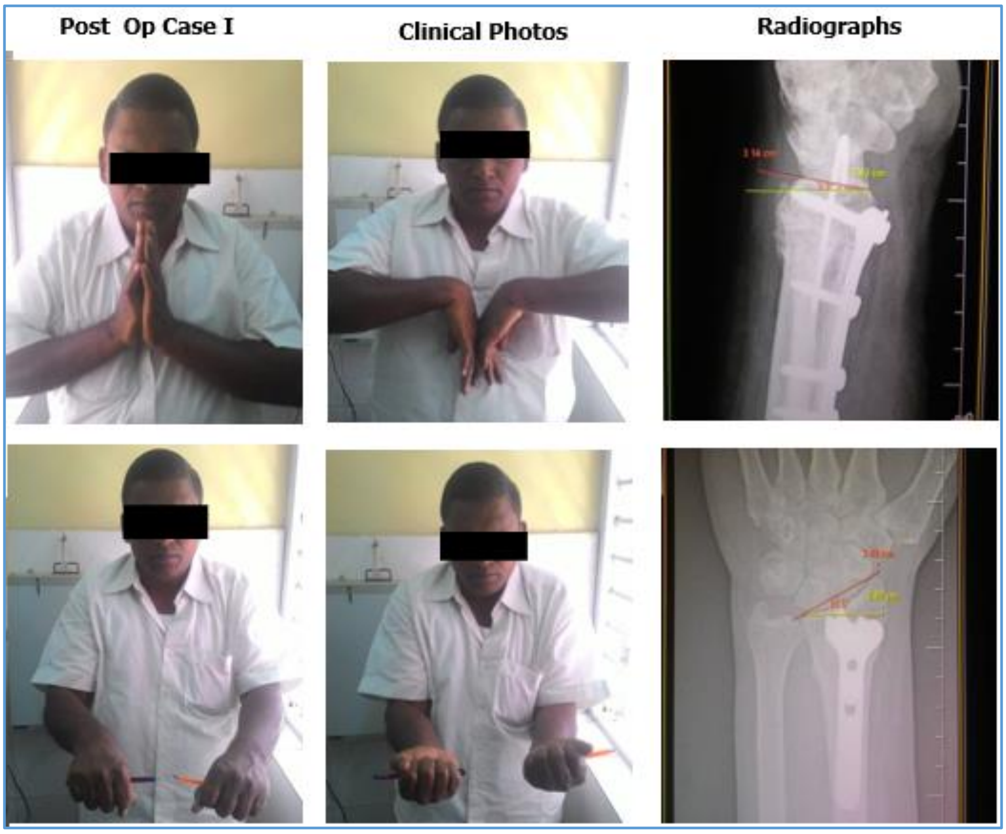
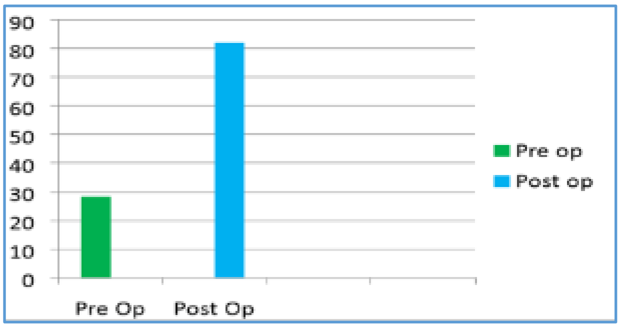
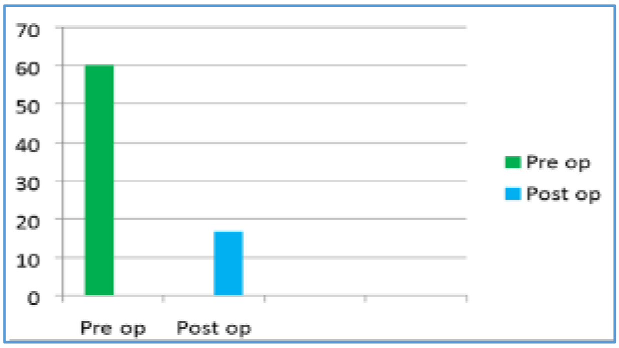


Figure 5. a) Postop Clinical Evaluation at 3 Months Showing Good Functional Recovery; b) Dorsal Deformity Corrected

Figure 6. a) Post op Clinical Evaluation at 3 Months Showing Good Functional Recovery; b) Dorsal Deformity Corrected



Graph 1. Modified Mayo Wrist Score



Graph 2. Mean DASH Score

DISCUSSION

Malunion of distal radius is a very common and disturbing complication of distal radius fracture mainly attributable to the ignorance prevalent within the community and lack of early attention to ailment. It can be associated with extra-articular deformities, intra-articular malalignment, distal radioulnar joint incongruity or instability or a combination of these features. Radiographic measurement of an intact distal radius shows an average of 22-23 degrees of radial inclination, 11-12 mm of radial height, 11-12 degrees of volar tilt with +2 mm ulnar variance.

Deformity of the distal radius may give rise to biomechanical changes to the carpus and radiocarpal joint. Restoration of the length and angulation is often a challenge. When there is a dorsal angle in the sagittal plane greater than 20 degrees, the contact surfaces and load axes undergo dorsal translation, thus giving rise to dorsal subluxation of the first row of the carpus, which increases the load per surface unit at the level of this joint by 50% with a dorsal tilt of 20% and reaches 67% with dorsal deformity of 45 degrees. Thus, a change at the center of rotation of the wrist is generated, which influences the normal translation of the tendons and reduces their lever arm, thereby causing a loss of strength of 50-60% in relation to the contralateral limb. Fernandez observed that fractures with more than 25 to 30 degrees of angulation in the frontal or sagittal plane or 6 mm or more of radial shortening were likely to be symptomatic. He also noted that constitutional joint laxity with midcarpal instability develops with a dorsal tilt of 10 to 15 degrees in the normal wrist. Approximately, 82% of the axial load is distributed onto the radius with the remaining 18% born by the distal ulna through the triangular fibrocartilage complex. With 2.5-mm radial shortening, this relationship changes, so that the ulna bears 42% of the axial load. Radial shortening of 10 mm reduced forearm pronation by 47% and supination by 29%.

Studies have demonstrated that corrective osteotomy, which restores anatomical configuration can effect an improvement in wrist function, forearm rotation, grip strength and pain. Fernandez obtained satisfactory results with an opening wedge metaphyseal osteotomy combined with reinsertion of a graft and internal fixation with a plate and screws. According to Fernandez, for patients treated by means of osteotomy of the distal radius, there should be an associated procedure to save the distal radioulnar joint.[10] However, if adequate radial length and inclination are obtained intraoperatively with bone grafting under fluoroscopy assistance, this step can be avoided. No ulna related procedure was performed in our study. A new technique for performing corrections on dorsal deformities of the radius by means of a conventional volar approach expanded to the FCR was recently described. Prommersberger and Flinkkila T have shown in their studies, the efficacy of corrective osteotomy by a volar approach.[11,12] Bone grafting can be done simultaneously through the same approach. Ozer et al study group noted the advantages of bone grafting in attaining faster and better union rates. Implants are precontoured to obtain desired angulation.[13]

By using a volar approach for performing osteotomy, it become possible to release the SS quadratus muscle. This is often shortened due to tearing and subsequent fibrosis caused by the fracturing of the distal radius. For this reason, almost complete recovery of supination was justifiable in our group of patients. Volar approach also has lesser tendon manipulation during surgery compared to dorsal approach and has an easy learning curve compared to dorsal approach. Rothenfluh et al group have compared dorsal and volar approaches for distal radius malunion and cited the benefits of volar approach like low tendon irritation problems and easy learning curve.[14]

Jupiter and Ring demonstrated that performing early osteotomy facilitates the surgical procedure (osteotomy by means of immature bone tissue with less soft tissue retraction and less instability of the distal radioulnar joint) and diminishes the time off work.[15,16] For this reason, young patients with dorsal angulation greater than 20 degrees should be considered to be in a precursor situation of the degenerative process (arthrosis) and a surgical procedure should be indicated. However, any person from working class population with a deformity of a working hand with permissible comorbidities is eligible for undergoing this procedure.

CONCLUSION

One unsolved mystery in this procedure is a residual DRUJ pain. Since, malunion takes its time to complete, regenerative potential of ligaments around DRUJ is lost and this can be difficult to restore surgically. We had 3 patients in our study that complained of DRUJ pain for 3 months. However, this pain was within the acceptable limits as per VAS scale and showed a decline by their 6th month follow up. Although, not completely eliminated, it was very minimal at their last follow up.

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