

An Hospital Based Observational Study Assessing Factors Associated with the Incidence of Radiocarpal Stiffness Following Management of Distal Radius Fractures Surgically

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Received: 10-08-2023 Revised: 22-08-2023 / Accepted: 17-09-2023

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Conflict of interest: Nil

Abstract

Aim: The aim of the present study to assess factors associated with the incidence of radiocarpal stiffness following management of distal radius fractures surgically.

Material & Methods: This study reviewed a series of patients who suffered from DRFs at Department of Orthopedics. The inclusion criteria were adult patients with closed DRFs confirmed by x-ray test or computed tomography (CT) scan and underwent surgical treatment with volar locking plate fixation. A total of 150 patients who underwent distal radius volar locking plate fixation were included in the current study.

Results: Among these patients, 40 (26.66%) were male, and 110 (73.33%) were female. The mean age at the time of surgery was 54.6 ± 10.6 with stiffness and 52.8 ± 9.1 without stiffness. Preoperative swelling was considered to be slight in 57 patients (38%) and was severe in 93 patients (62%). Extra-articular fractures were seen in 30 patients (20%), and intra-articular fractures were in 120 patients (80%). During surgery, 78 fractures (52%) were fixed with plate only, and the other 72 fractures (48%) were fixed with plate and Kirschner wire. The incidence of RJS, we found that age, preoperative swelling, types of internal fixation, fracture type, post-operative volar tilt and improper rehabilitation exercise were potential risk factors, while gender, BMI, history of smoking or alcohol, diabetes mellitus, osteoporosis, dominant hand, time from injury to operation, ulnar styloid process fracture, post-operative radial inclination, post-operative ulnar variance, assisted cast or splint fixation, postoperative infection, or removal of internal fixation was not. In the further multivariate logistic regression analysis, intra-articular fracture, pre-operative severe swelling, post-operative unsatisfied volar tilt and improper rehabilitation exercise were demonstrated to be associated with the incidence of RJS during follow-up.

Conclusion: Factors such as intra-articular extension, preoperative severe swelling, use of additional k-wire, unsatisfied volar tilt, improper rehabilitation is associated with a higher incidence of radiocarpal joint stiffness in patients with distal radius fracture. Re-operative risk notification and postoperative precautions are necessary for relevant patients.

Keywords: Wrist, Distal radius, Stiffness, Prognosis, Prevalence.

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Introduction

Distal radius fractures (DRFs) are the most common fractures of the upper limb and the most common fractures overall in individuals younger than 75 years. [1,2] There are two common variants of distal radius fractures that are characterized by the direction of forces applied to

the wrist during a fall: Colles' fractures, the most common type of distal radius fractures, which occur when falling on an outstretched hand, where the hand is extended backward on the wrist, and Smith fractures, which are caused by the opposite

mechanism, that is, when the hand is flexed forward under the wrist.

Distal radius fractures have a high incidence among the aging population and may potentially result in poor functional outcome and impairment. [3,4] As a common injury, it account for approximately one sixth of all fractures in emergency departments. [5,6] The incidence of distal radius fractures increases in women aged 65 and older due to the greater risk of osteoporosis.3 Postmenopausal women are likely to develop bone-related problems due to decrease in estrogen production, which has been shown to help prevent excessive bone breakdown.

Age-related fragility is a consequence of accelerated bone breakdown and increases the risk of developing osteopenia and osteoporosis. [7] Distal radius fracture represents 18% of all fractures in patients aged 65 and older, but anatomical reduction in these patients does not correlate with clinical outcome. This number may increase in the future due to the combination of a longer lifespan and low bone density. [8]

Traditionally, distal radius fractures in those over the age of 65 have been treated both non-surgically and surgically. Nonoperative (nonsurgical) options include immobilization with or without reduction, where the fractured bone is reduced without opening the skin and then subsequently immobilized to avoid potential displacement of fracture while healing. Although bone heals naturally, closed reduction can minimize the risk of infection, which is a rare but possible complication using surgical treatment. [9] For unstable fracture, volar plating is the most commonly used modality as it provides improved radiological parameter and better functional outcome as compared with conservative management. Patients could have an earlier return to normal activities with the reliable fixation of volar locking plate. [10,11,12]

With reliable fixation, patients could return to normal functions early. The main goal of the internal fixation is to obtain pain free motion, disability and to reduce early degenerative changes. Even with surgical management complications such as tendon rupture, loss of reduction, triangular fibrocartilage complex, wrist pain or radiocarpal joint stiffness is seen out of which radiocarpal stiffness which of much significance. [13] Though it is important to study these complications we have only very less studies. In this study, we analyse the distal fracture cases who underwent volar plating.

The aim of the present study to assess factors associated with the incidence of radiocarpal stiffness following management of distal radius fractures surgically.

Material & Methods

This study reviewed a series of patients who suffered from DRFs at department of Orthopedics, Katihar Medical College and Hospital, Katihar, Bihar, India for one year. The inclusion criteria were adult patients with closed DRFs confirmed by x-ray test or computed tomography (CT) scan and underwent surgical treatment with volar locking plate fixation. A total of 150 patients who underwent distal radius volar locking plate fixation were included in the current study.

Patients were excluded if they had previous DRFs, open fractures, bilateral DRFs, ipsilateral upper extremity injuries, or concomitant arterial or nerve injury.

Treatment and Follow-Up

All patients were performed open reduction and internal fixation after brachial plexus or general anesthesia. The locking plate is applied through an incision over the volar aspect of the wrist, and no dorsal approach was used. A standard flexor carpi radialis approach to the distal radius was applied. After exposure of the distal radius, reduction procedure was performed first, and volar locking plate with or without Kirschner wire was used to fix it. All operations were performed by three senior surgeons. The details of the surgical approach, the type of plate, and the number and configuration of screws were decided by surgeons. Some surgeons used a cast/splint after surgery, but the fixed angle stability provided by the locking plate is generally sufficient to allow early controlled range of movement exercises. The use or otherwise of a cast/splint was also at the discretion of surgeons. Finger, elbow, and shoulder exercises were started at the first day after surgery.

Routine follow-up was performed postoperatively at 2, 4, and 6 weeks and 3 and 6 months. At each visit, patients were asked to perform x-ray tests. At the 6 months follow-up, the range of radiocarpal joint movement was measured and recorded.

Data Collection

Associated factors were evaluated from three aspects, which are basic data, radiographic data, and postoperative data. The basic data were collected from medical record, such as age, gender, body mass index (BMI), habits, concomitant diseases, preoperative swelling, and time from injury to surgery. Preoperative swelling was assessed on the first day of hospitalization. If the wrist is swelling than the contralateral side but the skin texture can be recognized, the swelling was considered to be slight. If the skin texture cannot be recognized or blisters occurred, the swelling was considered to be severe.

There are five parameters in radiographic data. Fracture type and concomitant ulnar styloid process fracture were collected from preoperative radiograph, and volar tilt, radial inclination, and ulnar variance were measured from the radiograph at 6 months follow-up. Fracture type was divided into intra-articular fracture and extra-articular fracture according to whether the fracture line crosses articular surface. Volar tilt was measured on lateral radiograph by determining the angle between the line along the distal radial articular surface and the line perpendicular to the longitudinal axis of the radius at the joint margin. Radial inclination was measured on an anteroposterior (AP) radio-graph by determining the angle formed between the long axis of the radius and a line drawn from the distal tip of the radial styloid to the ulnar corner of the lunate fossa. Ulnar variance was measured on an AP radiograph using the method of perpendiculars. We identified the long axis of the radius and drew a line perpendicular to this, extending through the ulnar-most corner of the lunate fossa. The distance between this line and the distal-most point of the ulnar dome was recorded as the ulnar variance [20]. Wrist exercise advice was given by surgeons according to the status of fracture healing, which is a standard post-operative rehabilitation protocol including six wrist movements at a certain frequency. At the end of follow-up, patient compliance was asked about. Patients who followed the advice were considered to perform

proper wrist rehabilitation exercise; otherwise, they were considered to perform improper wrist rehabilitation exercise.

The radiocarpal joint movement after surgery was assessed with a goniometer. As flexion and extension of wrist are two most frequently used movements in our everyday life and can compensate for other wrist movements in most activities, we use the range of flexion-extension motion to assess the existence of RJS. The RJS was considered to present if the range of flexion-extension motion was no more than half of that in the contralateral side.

Statistical Analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 18.0. Variables were presented as a mean with standard deviation for continuous variables and with frequencies and percentages for categorical variables. The independent sample t test or Mann-Whitney U test was used for numerical data, and Fisher's exact test was used to identify differences in frequency of nominal variables between groups. After univariate analyses, variables found to be potentially associated with the RJS ($P < 0.20$) were included in the multivariate logistic regression models. P values less than 0.05 were considered to be statistically significant.

Results

Table 1: The comparison of basic data in patients with and without radiocarpal joint stiffness

| Variables | With stiffness (n = 50) | Without stiffness (n = 100) | P value |
|--------------------------------------|-------------------------|-----------------------------|---------|
| Age (years) | 54.6 ± 10.6 | 52.8 ± 9.1 | 0.03 |
| Gender | | | |
| Male | 15 | 25 | 0.82 |
| Female | 35 | 75 | |
| BMI (kg/m ²) | 22.8 ± 4.8 | 23.6 ± 4.3 | 0.68 |
| Smoker | | | |
| Yes | 10 | 18 | 0.95 |
| No | 40 | 82 | |
| Drinker | | | |
| Yes | 13 | 15 | 0.34 |
| No | 37 | 85 | |
| Diabetics | | | |
| Yes | 18 | 30 | 0.94 |
| No | 32 | 70 | |
| Osteoporosis | | | |
| Yes | 26 | 52 | 0.88 |
| No | 24 | 48 | |
| Dominant hand | | | |
| Yes | 28 | 58 | 0.58 |
| No | 22 | 42 | |
| Time from injury to operation (days) | 3.8 ± 2.6 | 3.6 ± 2.7 | |
| Preoperative swelling | | | |
| Slight | 12 | 45 | 0.01 |

| | | | |
|--------------------------|----|----|------|
| Severe | 38 | 55 | |
| Internal fixation | | | |
| Plate only | 20 | 58 | 0.20 |
| Plate and Kirschner wire | 30 | 42 | 0.22 |

Among these patients, 40 (26.66%) were male, and 110 (73.33%) were female. The mean age at the time of surgery was 54.6 ± 10.6 with stiffness and 52.8 ± 9.1 without stiffness. Preoperative swelling was considered to be slight in 57 patients (38%) and was severe in 93 patients (62%). During surgery, 78 fractures (52%) were fixed with plate only, and the other 72 fractures (48%) were fixed with plate and Kirschner wire.

Table 2: The comparison of radiographic data in patients with and without radiocarpal joint stiffness

| Variables | With stiffness (n = 50) | Without stiffness (n = 100) | P value |
|--|-------------------------|-----------------------------|---------|
| Fracture type | | | |
| Extra-articular | 6 | 24 | 0.07 |
| Intra-articular | 44 | 76 | |
| Ulnar styloid process fracture | | | |
| Yes | 20 | 40 | 0.80 |
| No | 30 | 60 | |
| Post-operative radial inclination (degree) | 18.2 ± 3.6 | 20.2 ± 3.8 | 0.26 |
| Post-operative volar tilt (degree) | 6.8 ± 1.6 | 7.3 ± 1.7 | 0.01 |
| Post-operative ulnar variance (mm) | 0.4 ± 0.3 | 0.5 ± 0.3 | 0.33 |

Extra-articular fractures were seen in 30 patients (20%), and intra-articular fractures were in 120 patients (80%).

Table 3: The comparison of postoperative data in patients with and without radiocarpal joint stiffness

| Variables | With stiffness (n = 50) | Without stiffness (n = 100) | P value |
|---------------------------------------|-------------------------|-----------------------------|---------|
| Fracture type | | | |
| Yes | 15 | 35 | 0.58 |
| No | 35 | 65 | |
| Ulnar styloid process fracture | | | |
| Yes | 2 | 5 | 0.64 |
| No | 48 | 95 | |
| Fracture type | | | |
| Yes | 24 | 60 | 0.02 |
| No | 26 | 40 | |
| Removal of internal fixation | | | |
| Yes | 30 | 65 | 0.45 |
| No | 20 | 35 | |

The incidence of RJS, we found that age, preoperative swelling, types of internal fixation, fracture type, post-operative volar tile and improper rehabilitation exercise were potential risk factors, while gender, BMI, history of smoking or alcohol, diabetes mellitus, osteoporosis, dominant hand,

time from injury to operation, ulnar styloid process fracture, post-operative radial inclination, post-operative ulnar variance, assisted cast or splint fixation, postoperative infection, or removal of internal fixation was not.

Table 4: Multivariate logistic regression analysis of factors associated with radiocarpal joint stiffness

| | P value | Odds Ratio | 95% CI |
|--|---------|------------|-----------|
| Elder age (≥ 60 years) | 0.28 | 1.18 | 0.90–1.53 |
| Internal fixation (plate and Kirschner wire) | 0.39 | 1.17 | 0.83–1.61 |
| Fracture type (intra-articular) | 0.03 | 1.45 | 1.13–1.81 |
| Pre-operative swelling (severe) | 0.04 | 1.38 | 1.05–1.74 |
| Post-operative volar tilt ($\leq 7^\circ$) | 0.04 | 1.40 | 1.01–1.89 |
| Improper rehabilitation exercise | 0.02 | 1.70 | 1.18–2.51 |

In the further multivariate logistic regression analysis, intra-articular fracture, pre-operative severe swelling, post-operative unsatisfied volar tile and improper rehabilitation exercise were

demonstrated to be associated with the incidence of RJS during follow-up.

Discussion

The incidence of distal radius fractures increases in women aged 65 and older due to the greater risk of osteoporosis. [14] Postmenopausal women are likely to develop bone-related problems due to decrease in estrogen production, which has been shown to help prevent excessive bone breakdown. Age-related fragility is a consequence of accelerated bone breakdown and increases the risk of developing osteopenia and osteoporosis. Consequentially, 85% of elderly women exhibit low bone density and 51% have osteoporosis. [15] Conversely, men have less severe fractures than women in part due to the reduced prevalence of osteoporosis.5 Moreover, dual-energy X-ray absorptiometry scans revealed higher bone mineral density in men than in women. [16] Distal radius fracture represents 18% of all fractures in patients aged 65 and older, but anatomical reduction in these patients does not correlate with clinical outcome. This number may increase in the future due to the combination of a longer lifespan and low bone density. Nellans et al reported that women who suffered a wrist fracture were 50% more likely to report a functional decline when compared to women without fractures. [17]

Among these patients, 40 (26.66%) were male, and 110 (73.33%) were female. The mean age at the time of surgery was 54.6 ± 10.6 with stiffness and 52.8 ± 9.1 without stiffness. Preoperative swelling was considered to be slight in 57 patients (38%) and was severe in 93 patients (62%). Extra-articular fractures were seen in 30 patients (20%), and intra-articular fractures were in 120 patients (80%). During surgery, 78 fractures (52%) were fixed with plate only, and the other 72 fractures (48%) were fixed with plate and Kirschner wire. Our result showed that intra-articular fracture was associated with a diminished flexion/extension arc. Intra-articular fracture usually involves step-offs and gaps, which can result in residual articular incongruence even after surgical treatment. Karnezis et al [18] analyzed different types of fractures and concluded that the presence of postoperative articular incongruity of 1 mm or more is associated with persisting loss of wrist dorsiflexion and wrist joint dysfunction at 1 year following injury. Previous studies also showed that persistent intra-articular incongruity may cause a 9-fold increased risk of radiological osteoarthritis. [19,20] We think that restoration of the articular surface and maintenance of joint congruity were essential for good postoperative wrist movement.

The incidence of RJS, we found that age, preoperative swelling, types of internal fixation, fracture type, post-operative volar tilt and improper rehabilitation exercise were potential risk factors, while gender, BMI, history of smoking or alcohol, diabetes mellitus, osteoporosis, dominant hand,

time from injury to operation, ulnar styloid process fracture, post-operative radial inclination, post-operative ulnar variance, assisted cast or splint fixation, postoperative infection, or removal of internal fixation was not. In the further multivariate logistic regression analysis, intra-articular fracture, pre-operative severe swelling, post-operative unsatisfied volar tilt and improper rehabilitation exercise were demonstrated to be associated with the incidence of RJS during follow-up. Three parameters used to assess distal radius deformity are Volar tilt, radial inclination and radial shortening. [21] In certain cases, perfect anatomic reduction is very hard or almost impossible. If the residual dorsal angulation was $\leq 10^\circ$, radial inclination was $\geq 15^\circ$, and radial shortening with positive ulnar variance was < 3 mm was considered acceptable based on Grewal and MacDermid's study. [22] Postoperative volar tilt if unsatisfactory, is by itself an independent variable of RJS. Exaggerated dorsal angulation of more than 20 degree may worsens functional outcome. [23,24]

Postoperative rehabilitation exercise is important for orthopedic surgery. A home exercise was considered to be as effective as formal physical therapy [25], but controversy still exists in other problems, for example, the timing of postoperative immobilization. A prospective randomized study compared early wrist exercise (i.e., within 2 weeks of surgery) with late wrist exercise (i.e., 6 weeks) in DRFs patients treated with volar plate fixation, and concluded that no significant differences were identified with respect to the average flexion-extension arc of the injured wrist at 3 or 6 months follow-up. [26] In our study, the lack of exercise within 3 months is common in these patients with improper rehabilitation exercise. We inferred that early or late exercise may not significantly affect the RJS, but the lack of exercise dose. Doctors' advice and patients' compliance during follow-up are essential for RJS prevention.

Conclusion

Nearly half of the patients with distal radius fractures presented with post-operative radiocarpal joint stiffness following open reduction and internal fixation with a volar locking plate. An increase in age, peri-operative swelling, type of internal fixation, volar tilt, improper rehabilitation exercises were associated with the incidence of radiocarpal joint stiffness. However, volar tilt seems to be more dangerous than the restoration of radial inclination and radial shortening for wrist dorsiflexion movement. Proper precautions and necessary measures should to be taken pre - operatively and post-operatively for these patients.

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