Displaced Distal Radius Fractures Presented Late: A Randomized, Prospective Comparative Study of Two Methods of Treatment

M Radwan

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Abstract
BACKGROUND AND AIM OF THE WORK: Fractures of the distal radius are common, yet there is no clear consensus on their management. A fracture that slips after reduction should be considered to be unstable and probably requires fixation. Late-presenting cases come with more complexity. This study aims to evaluate the early results of a minimally invasive surgery by the modified Kapandji technique versus invasive surgery through open reduction and internal fixation by plate and screws in treating these challenging fractures. RESEARCH DESIGN AND METHODS: Prospective study restricted for those adult patients with displaced distal radius fractures presented within 3 to 6 weeks from date of injury. The study patients were randomly divided into two groups each one included 23 patients. Group I, managed with Kapandji method, as modified by Fritz et al. and group II was treated by the conventional open reduction and internal fixation by plate and screws. RESULTS: The result at final follow-up was excellent in 63.2%, good in 26.3%; fair in 10.5% and no poor results in group I compared to 66.6% excellent, 23.9% good, 9.5% fair and no poor results in group II. CONCLUSIONS: Excellent to good results can be achieved in most of cases. As no significant difference in outcome between the two ways, the modified Kapandji technique is preferred as it is less invasive, easy to perform, less costly and time saving.

INTRODUCTION
Fractures of the distal radius are the most common of all orthopedic injuries accounting for nearly 20% of all fractures presenting to accident and emergency department.1 It is the fracture of all age groups although it is common in the elderly because of the frequent osteopenia and osteoporosis.2,3 Closed reduction and immobilization in plaster cast remains an accepted method of treatment for majority of stable fractures.1,2,3,4 MacKenney et al.5 show that late instability occurs in 22% of fractures that initially presented with minimal displacement and of those patients who presented with displaced fractures, early instability occurs in 43% overall after reduction.

A fracture reduction that slips should be considered to be unstable and probably require fixation with percutaneous pins, open reduction and internal fixation (ORIF) by plate and screws or wires or external fixator.6,7 At the same time, fractures of the distal radius require an anatomic reduction, as even minimal step-off of articular surface is associated with the development of osteoarthritis.8,9 Fourrier et al.8 state that the lower limits of deformity, at which symptoms are likely to be present, are a radial deviation of 20°–30°, a sagittal tilt of 10°–20°, and a radial shortening of 2 mm.

The rating system proposed by Fernandez6 for classification of distal radius fractures is based on mechanism of injury. He says that; this rating was created to be practical, predict stability, check on associated fractures of the ulna styloid process, and make general recommendations for treatment.6,12 (Table I)

Figure 1
Table 1: Fernandez Classification of Distal Radius Fractures

The goals of treatment for displaced distal radius fractures have always been to restore the anatomy of the radius length,
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In contrast to articular involvement, the articular congruency and joint surface in addition to maintenance of a stable reduction. Newer techniques and devices make that goal more attainable than ever before. Nevertheless, no one technique is always best, and a return to normal may not be possible, regardless of treatment. Moreover, Brian Moore proved that many cases of distal radius may necessitate bone graft or bone graft substitutes and indications and choice should be based on the individual case requirement regarding structural support, gap filling or bone healing stimulation.

Late-presenting distal radius fracture with displacement or collapse put in more difficulties as regard the treatment modality, the way for reduction, the method of fixation and the need for bone grafting and early mobilization. Hence this study was designed to evaluate and compare outcome of a minimally invasive surgery through the Kapandji method versus more invasive surgery by the conventional ORIF by plate and screws in treating that difficult fractures.

PATIENTS AND METHODS

This study has been done in King Abdulaziz Hospital, Holley Makkah, Kingdom of Saudi Arabia from February 2005 to October 2008. It was prospectively designed and included 46 consecutive adult patients with displaced distal radius fractures presenting not on time but 3-6 weeks from date of injury. Radial height less than 6 mm, Radial inclination of less than 14°, a sagittal tilt on the lateral projection between 15° dorsal and 20° volar angulation or intra-articular fracture step-off more than 2 mm of the radiocarpal joint were the radiographic findings in patients that indicated surgery and included in my series. Patients who are skeletally immature, recent fractures less than 3 weeks, old fractures more than 6 weeks, concomitant scaphoid fractures or other hand injuries that impact functional recovery were excluded.

The study patients were divided randomly into two groups each one included 23 patients. Group I managed with Kapandji method, as modified by Fritz et al. in which two Kirschner wires are inserted into the fracture gap and a third is placed through the radial styloid process. Group II was treated by the conventional ORIF by plate and screws. For every one, plain radiographs of both wrists were included in the preoperative assessment. The degree of injury to the radius including displacement, comminution, and articular involvement along with other injuries to the wrist were recorded. CT scan was performed mainly in intra-articular fractures to investigate the articular anatomy of the fracture. All Fractures were classified using Fernandez classification.

Full data were gathered on 19 patients from group I and 21 from Group II who were accessible for at least one year during follow-up. Group I included 6 woman and 13 men with age range from 25 to 63 years and group II comprised 5 women and 16 men with age range from 22 to 66 years.

SURGICAL TECHNIQUE

For group I: Reduction was gifted by inserting Kirschner wires into the fracture gap (intrafocal pinning) through small incision just distal to the fracture site and utilizing them as levers to reduce the fragments. The first K-wire is the lateral one to reduce radial translation. The second one or two lay dorsal in dorsally displaced fracture or volar in volarly displaced fracture in line with the second metacarpal bone to correct the sagittal deformity. As a practice, all K-wires were slipped under vision on the bone towards the fracture site, then pass through the fracture for a short distance and then adjusted to make an angle about 45° to pass toward the opposite cortex of the proximal fragment. All these steps were carried out using the T-handle and image intensifier. The position at the fracture site still can be adjusted more using the pins as a lever until the proper anatomy is restored. The wires were then advanced to be anchored in the proximal cortex. Additional wire was inserted after reduction through the radial styloid to engage both distal and proximal fragments together to add more stability.

Disengaging the sticky old fracture with the help of fine peristeal elevator was usually done when necessary, from the same incisions. In two cases, bone defect was encountered after reduction and so bone graft substitute was necessitated to fill and support.

For group II: Conventionally, dorsally displaced distal radial fractures have been approached dorsally, and palmary displaced fractures planned to be reduced and fixed from the palmar side. There was a routine use of a radiolucent hand table, tourniquet on the arm and image intensification to assess reduction and fixation. The idea was to put the plate centered on the radius hugging the approached surface. The reduction was optimized by traction, fragment manipulation, and proper help from the assistant. Temporary use of K-wires could be helpful as well. An inclined lateral view (20° to 25°) could assess both articular congruency and
periarticular screw placement to ensure no fixation is intra-articular. The reduction was maintained by proper screw placement, appropriate screw length, and sufficient screw numbers. Transfixing wire to augment lateral column fixation was needed in seven cases.

In three cases with bone loss, adjunctive use of bone substitute was necessary. In one case of delayed union, iliac bone graft was added to promote and enhance bone healing.

**POSTOPERATIVE CARE AND FOLLOW-UP**

All patients in group I had a postoperative splint for 3-5 weeks while for 2-3 weeks only in group II. After that, the patient can start gentle range of movement exercises and use a removable splint for comfort. K-wires were removed in outpatient clinic usually between 5 and 6 weeks depending on the progress of bone healing. At 6 weeks, the fracture was usually united and the patient could be managed without extra support. Official physical therapy could then be started. Complications were recorded and graded by severity. It is well known that maximum recovery could take months or even a year.

Radiological results were judged on the roentgenographic appearance immediate post operative, 2 weeks postoperative and at follow-up visits according to the text book reduction criteria.\[24\] Patients were evaluated for pain, range of movement (ROM), the grip strength and work status as measured by the modified wrist score \[25\]. Total point score 100 points: excellent (91 to 100), good (80 to 90), fair (65 to 79), and poor (<64). Clinical results were traced at 6 weeks, 3 months, 6 month, one year and at final follow-up.

Data were shown as mean ± SD (standard deviation). Statistical evaluations were carried out using SPSS software version 12. Paired t tests were performed and the level of significance was set at p<0.05.

**RESULTS**

**RADIOLOGICAL RESULTS**

CT scan was performed in 12 out of 46 patients mainly in intra-articular fractures. All patients had union, whereas delayed-union occurred in one patient in group II in whom highly comminuted fracture was treated by plate and screws and united after iliac bone grafting. The mean time to union was 6 weeks (range 4 to 11) in group I and 7 weeks (range 6 to 13) in group II.

At one year follow-up, the mean radial inclination angle was improved from 7.74° (±3.26) to 18.31° (±3.35) in group I and from 7.19 ° (±2.64) to 18.09 ° (±3.19) in-group II. The mean radial height in patients of group I improved from -2.68 mm (±4.12) to 9.37 mm (±1.64) and from -2.76 mm (±3.36) to 10.00 mm (±2.00) in group II. The mean dorsal angle in the patients presented with dorsal angulation was corrected from 29.50 ° (±7.34) to 1.20° (±1.135) in group I and from 28.73° (±9.01) to 1.45 (±1.57) in-group II. The mean volar angle in patients with volar angulation was improved from 28.80 (±8.79) to 0.40(±.89) in group I and from 26.00 (±7.80) to 0.33 (±0.82) in group II. (Table II)

No significant differences in the mean radiological results between the two groups (p>0.05).

In the nine intra-articular fractures in group I that are examined in the immediate postoperative period; 6 had a step-off of 2 mm and 3 had a step-off of >2 mm while in 12 fractures in group II 10 had a step-off of 2 mm and 2 had a step-off of >2 mm. At one year follow-up, in group I; 5 had no step-off, 2 had a step-off of 2 mm and 2 had a step-off of >2 mm, while in group II, 9 had no step-off, 2 had a step-off of 2 mm and one had a step-off of >2 mm.
CLINICAL RESULTS

The mean follow-up was 15 months (range 12 to 17 months). Nineteen patients from group I and 21 from Group II accomplished evaluation for at least one year with follow-up rate of 82.6% and 91.3% respectively. Group I included 14 right sides which were the dominant and 5 left side in 6 woman and 13 men with mean age 48.68 years (range 25 to 63). In group II; 13 dominant sides and 8 non-dominants in 5 women and 16 men with mean age 48.52 years (range 22 to 66). Wrist pain, deformities and limitation of movements were the presenting symptoms in all patients. The mean time of chronicity of the fractures to date of surgery was 30.53 days in group I (range 21 to 41) and 31.00 days (range 23 to 42) in group II. Failure of non-operative treatment was the common cause of late presentation seen in 24 cases (11 groups I and 10 groups II), carelessness in 16 cases (5 group I and 8 group II) and failure of previous surgery in 6 cases (3 in group I and 3 in group II). Two out of the six; redisplaced after Kapandji technique revised by modified Kapandji again and bone grafting, 2 displaced after plate removal; one to overcome infection managed by modified Kapandji and the other due to implant failure revised by supporting bone graft substitute and again fixation by plate and screws. The last two cases presented with percutaneous transfixing wires with inaccurate reduction revised by plate and screws with grafting. Their were, ten fractures Fernandez type 1 (six dorsal and four volar displacement), two type 2 (one dorsal and one volar), three type 3, one type 4 and three type 5 in group I. While in group II, eight fractures were classified as type 1(five dorsal and three volar displacement), two type 2 (one dorsal and one volar), six type 3 (five complex and one pilon), three type 4 and two type 5. (Table I &Table III)

Figure 3

Table 3: Demographic data of the late-presenting patient’s with fractures of the distal radius treated either by modified Kapandji (group I) or ORIF by plate and screws (group II).

Intraoperative, no neurovascular injury and no tendon hurt occurred in both groups. The average operation time was 43.21 minutes per fracture in group I while 76.76 minutes in group II.

At one year follow-up, the mean Mayo modified wrist score was improved significantly in both groups from 48.37(±13.83) preoperatively to 83.74(±08.80) in group I and from 46.33 (±14.22) preoperatively to 84.05 (±10.97) in group II. (Table IV). Wrist pain was completely relieved or highly improved in all cases. The mean ROM were 41.2 ° of flexion, 40.5 ° extension, 8.7 ° radial deviation, and 15.4 ° ulnar deviation in group I, while 40.8 ° of flexion, 40 ° extension, 8.7 ° radial deviation, and 15.8 ° ulnar deviation in group II. Compared with the contralateral side, pronation and supination were 86% and 85% in group I while 88% and 86% in group II respectively. The mean grip strength reached 76.8% of the normal side in group I and 79 % in group II. All patients returned to their previous work status within 3 months (range 1 to 4) from date of surgery in group I and within 2.5 months (range 1 to 3) in group II.

In patients followed after one year follow-up, no more significant radiological or clinical improvement observed in patients of both groups.
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**Figure 4**

Table 4: The mean age, the mean duration of delaying, the mean operation time and the Mean Modified Mayo Wrist Score (± SD) preoperative, at 6 weeks, 3 months, 6 months and at one year follow-up.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group I</th>
<th>Group II</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yr) (±SD)</td>
<td>46.68 ± 9.35</td>
<td>46.52 ± 9.30</td>
<td>0.835</td>
</tr>
<tr>
<td>Duration of delaying (days) (±SD)</td>
<td>30.82 ± 7.54</td>
<td>31.00 ± 6.90</td>
<td>1.000</td>
</tr>
<tr>
<td>The mean operation time (minutes)</td>
<td>43.21 ± 15.89</td>
<td>76.79 ± 17.48</td>
<td>0.000</td>
</tr>
<tr>
<td>Mean Modified Mayo Wrist Score</td>
<td>Immediate postoperative</td>
<td>48.37 (±13.83)</td>
<td>46.33 (±14.22)</td>
</tr>
<tr>
<td></td>
<td>At six weeks</td>
<td>60.26 (±12.88)</td>
<td>50.57 (±10.03)</td>
</tr>
<tr>
<td></td>
<td>At six months</td>
<td>78.31 (±68.14)</td>
<td>78.14 (±68.23)</td>
</tr>
<tr>
<td></td>
<td>At one year</td>
<td>91.24 (±59.50)</td>
<td>92.14 (±59.94)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>83.74 (±60.80)</td>
<td>84.90 (±61.97)</td>
</tr>
</tbody>
</table>

(Statistically significant: P<0.05. Statistically highly significant: P<0.005)

As regard the operation time, there is high significant difference between both groups (P<0.005), while insignificant differences in the mean age, duration of delaying and wrist score between the two groups (p>0.05).

The final clinical results were; 12 out of 19 excellent (63.2%), 5 good (26.3%), 2 fair (10.5%) and no poor in group I compared to 14 out of 21 excellent (66.6%), 5 good (23.9%), 2 fair (9.5%) and no poor in group II. Fig. 1 & Fig. 2

**Figure 5**

Figure 1: (A&B) Preoperative AP and lateral radiographs for young man patient presented late, 3 weeks from date of injury with radial shortening, decrease in radial inclination angle, dorsal comminution and angulated ulnar fracture. (C&D) Postoperative follow-up AP and lateral radiographs. The distal radius fracture and ulna fracture are well stabilized using small DCP with augmentation by K wire through the radial styloid getting restoration of radial length and radial inclination while radial tilt was reversed due to dorsal comminution. (E&F) Final follow-up radiographs; the fracture is healed in good alignment. (G&H) Final clinical outcome; full ROM and normal muscle power.
Figure 8

Figure 7: (A&B) AP and lateral radiographs for young male patient showing intra-articular distal radial fracture, presented four weeks from date of injury. (C&D) Postoperative AP and lateral radiographs using a modified Kapandji technique verify restoration of radial length, radial inclination, palmar tilt and intra-articular gap obliteration. (E&F) Follow-up, AP and lateral radiographs. (G&H) Final, AP and lateral radiographs; the fracture is healed in good alignment. (I&J&K&L&M&N) Final clinical outcome.

Figure 9

Figure 10
Twenty-five complications were seen, 14 of which were considered minor; recovered without surgical intervention and did not affect the final results and 11 major complications, some treated surgically while others still need further intervention. In group I, there were 9 minor complications; 3 cases of tendinites, 5 superficial pin tract infection and one sympathetic dystrophy while major complications were 6; 2 loss of reduction, 2 malunion and 2 carpal tunnel syndrome. In group II; 5 minor complications including 3 tendinites, one superficial infection and one sympathetic dystrophy and 5 major; one deep infection, one tendon rupture, one delayed union and 2 malunion.

**DISCUSSION**

Intraoperatively with the modified Kapandji technique, the anatomical landmarks are easier to identify, reduction is easier by the help of intrafocal pins, and imaging is easier to interpret. Also bone graft is not required except in two old patients’ necessitated hard blocks of bone substitute to fill defects encountered after reduction. Moreover, on average the operating time is reduced by 43% and time to union was one week less than in patients treated by the conventional ORIF by plate and screws. Of course, this is related to the simple and less invasive technique which was used in group I. So it can be said that the use of modified Kapandji technique achieves the goal of surgical treatment of late-presenting distal radius fractures through restoration of the alignment and articular surface congruity although it is simple and less costly.

Reversed displacement from volar to dorsal occurred in two cases in group I: one young patient due to slipping of the radial pin volarly adding more force on palmar aspect.
Patient was re-operated by removal of the slipped wire, reduction of the fracture; refitting it mid laterally anchoring in the proximal cortex and adding one more wire trans-styloid engaging both the proximal and distal fragments. The second case was an old lady with osteoporotic bone as pins lost their hold in the distal fragment. It was easy to reduce and fix with the help of a dorsal pin passing intrafocal, used as a lever to correct dorsal displacement and pushed to engage the volar cortex to maintain reduction. Bone graft substitute in the form of hard cubes was added more in the bone defect to prevent collapse in the presence of extensive dorsal comminution. So still by Kapandji technique can do revision and add bone graft or bone substitute through less invasive surgery with no more harm.

At 6 weeks and 3 months, patients treated with ORIF by plate and screws recovered good or excellent function including; pain relieve, ROM and grip strength faster than those treated with the modified Kapandji technique. Although differences were statistically insignificant, further improvements were observed to continue in group I to be nearly the same for both groups in patient’s seen at final follow-up. This suggests that the modified Kapandji fixation group tend to reach outcome of the plate system group over time.

I do not agree with Wayne et al.[22] who says that modified Kapandji technique is indicated mainly for the treatment of unstable extra-articular or minimally displaced intra-articular fractures of the distal radius as excellent to good results could be achieved also in cases with Fernandez type 3, type 4 and type 5 fractures in our series in group I patient’s. This agrees with others [30] also who noted that the results are uniformly excellent by subjective criteria, even for Smith’s type fractures and intra-articular fractures. In the same time, results in group I coincide with Trumble and colleagues [31] who show that intrafocal pinning in patients less than 55 years of age with comminution of a single cortex would yield a 96% chance of a good and excellent result when combined with casting for treatment of extra-articular distal radius fractures.

ORIF by plate and screws is able to correct intra-articular lesions with comminution in elderly and in younger patients and can be placed to the dorsal or volar side of the fracture according to the direction of displacement.[222] Alan et al.[13] state that ORIF may be used to achieve fracture restoration and stability throughout the entire healing process without protruding wires or pins and allow early intensive rehabilitation. Also Beharrie et al.[31] suggest that ORIF with plates and screws in treatment of patients with displaced and comminuted fractures of the distal radius represents a safe and effective treatment alternative. My results in group II also are consistent with previous studies.

One case of major complication occurred in group II in a patient who had fallen from a height, resulting in a Grade I open fracture of the ulna. Her radius fracture was intra-articular and severely comminuted and internally fixed by plate and screws. Infection occurred then implants were removed and replaced by intrafocal pinning but reduction was not satisfactory. A case of malunion in group II occurred in a sixty-three-year- old female who fractured her wrist by a fall from a height with osteoporotic bone. Marked comminution and injury to the distal radio-ulnar joint were most probably the cause. A case of ulna plus in group II was in heavy smoker middle aged male patient with fracture presented late six weeks and the bone was very soft and collapsed.

In intra-articular fracture of both groups of patients, the clinical results at final follow-up are nearly equal in contrast to the radiological ones which are slightly better in cases of group II. The balance between restoration of precise articular congruity in group II and minimized disruption and “devitalization” of articular fragments through limited dissection in group I may be the cause. So my study arrives at the same conclusion of David [4] who established that the final functional result does not seem to depend exclusively on only excellent anatomic reduction and ideal postoperative radiological views. This is because the severity of lesion does not only depend on the type of fracture, but also on the possible and similar lesions of ligaments, vessels and nerves and also the trauma of surgery from which extent of participation affects the final functional result.

Reflex sympathetic dystrophy is a disabling complication after fracture of the distal radius. Two cases were encountered; one for each group, perhaps related to the patient's lack of cooperation to move the fingers and then the wrist before and after surgery. Patient improved on physiotherapy.

Our results for the treatment of late-presenting displaced distal radial fractures with the modified Kapandji technique or ORIF was promising and consistent with the results of many studies for operative treatment of recent fractures [16,17,20,22,23,27]. So, I can believe that cases of distal radius...
fracture presenting late are still amenable for surgical treatment and a cure should always be attempted in all patients, with the exception of cases already involving severe osteoarthritis or malunion.

CONCLUSIONS
Displaced distal radius fracture presenting-late can be successfully treated by using either modified Kapandji technique or ORIF by plate and screws with insignificant difference at end results. The simplicity, the less cost, the easier to interpret intraoperative imaging, the shorter period of surgery and more important, the reliability of the modified Kapandji technique give it the priority to treat these challenging fractures.

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Author Information

Makram Radwan, M.D.
Orthopaedic Department, Zagazig University