

A STUDY ON FRACTURE FIXATION OF DISTAL END OF RADIUS BY PERCUTANEOUS PINNING

Kiran Kumar L¹, Mukherjee G. S², Manikumar C. J³, Ramachandrudu M⁴

¹Assistant Professor, Department of Orthopaedics, Rangaraya Medical College, Kakinada, Andhra Pradesh.

²Associate Professor, Department of Orthopaedics, Rangaraya Medical College, Kakinada, Andhra Pradesh.

³Assistant Professor, Department of Orthopaedics, Rangaraya Medical College, Kakinada, Andhra Pradesh.

⁴Postgraduate, Department of Orthopaedics, Rangaraya Medical College, Kakinada, Andhra Pradesh.

ABSTRACT

BACKGROUND

Various treatment modalities have been described for the treatment of distal radius fractures each with its own merits and demerits. Most of the work done with percutaneous pinning has shown a significant residual stiffness of the hand and wrist. Our technique involves percutaneous pinning of the fracture and immobilisation in neutral position of the wrist for. This study's aim was to examine the functional outcome of percutaneous K-wiring of these distal radius fractures with immobilisation in neutral position of the wrist.

METHODS

A prospective study conducted on thirty adult patients with distal radial fractures treated at Department of Orthopaedics, Rangaraya Medical college, Kakinada between October 2013 to September 2015.

RADIOGRAPHIC EXAMINATION

Standard radiographs in PA and lateral views were taken for confirmation of the diagnosis and also to know the type of fracture. Oblique views were also taken in a few patients who had complex comminuted fractures. The fracture fragments were analysed and involvement of radiocarpal and distal radioulnar joints were assessed and classified according to the Frykman classification. Of the cases, 6(20%) of the fractures were type I, 2(6.6%) of type II, 3(10%) of type III, 6(20%) of type IV, 8(26.6%) of type V, 5(16.6%) of type VI, no cases of type VII and VIII.

SURGICAL PROCEDURE

The procedures were performed under regional anaesthesia in all cases. After sterile preparation and draping, fracture is reduced by traction and the reduction was evaluated fluoroscopically. A 1.5 cm incision given longitudinally (if needed) beginning at the radial styloid and proceeds proximally across to the medial metaphysis and diaphysis. At least two pins (1.6 mm Kirschner wire) were inserted and adequate reduction was confirmed on AP/LAT views under image intensifier. Another 1.6 mm K-wire percutaneously 90 degrees orthogonally to these wires starting at the dorsal rim of distal radius just distal to the Lister's tubercle. The correct starting point confirmed with fluoroscopy and the wire is driven in a proximal and volar direction across the fracture site to engage the volar cortex of the radius proximal to the fracture. Additional wires were passed as necessary to secure additional fracture fragments. The wires were bent and cut leaving them superficial to the skin. The radial styloid incision was closed with interrupted absorbable sutures. A below elbow POP slab was applied. The pins were removed between 4 to 6 weeks. Postoperative pain and inflammation were managed using anti-inflammatory drugs, diclofenac sodium 50 mg twice daily, and serratiopeptidase. All patients were given oral ceftriaxone 200 mg twice a day for 5 days. Patients were asked to perform active finger movements from day one. Immediate postoperative check x-rays were taken in both PA and lateral views. The reduction of the fracture was confirmed and any displacements were noted. Patients were discharged after the 5th postoperative day and advised active exercises. On followup at 2nd, 4th, 6th weeks and, 6th, 12th, 18th months, the fracture union was assessed clinically by absence of tenderness and radiologically by bridging callus formation. Below elbow slab was removed by 4 wks. and patient is advised for active movement of wrist (Fig. 5 and 6). Then, K wires were removed without anaesthesia on an outpatient basis by 4-6 wks. The patients were advised to defer lifting heavy weights for further 4 to 6 weeks. After discharge, all patients were reviewed weekly for the first 6 weeks. Patients were assessed subjectively for pain at the fracture site clinically for tenderness, loosening of the pins, and any signs of infection. Pronation and supination of the forearm and active movement of the elbow and shoulder were advised throughout the period of healing. After the 6th week, physiotherapy was initiated. The range of wrist movements was recorded and any deformity was assessed.

RADIOGRAPHIC ASSESSMENT

Check x-rays were taken at 12 weeks to assess consolidation or collapse at the fracture site and to note any displacement. The fracture was considered united when clinically there was no tenderness, subjective complaints, and radiologically when the fracture line was not visible. Malunion was defined as more than 5 mm radial shortening, more than 15° of volar tilt or more than 10° dorsal tilt, and more than 4 mm of radial shift. 60 arthritic changes were graded according to the system described by Knirk and Jupiter. 61 regular followup was done at an interval of 6 weeks, 6 months, 12 months, and 18 months. The results were assessed at 3 months after the procedures using the DASH score.

RESULTS

The present study consists of 30 cases of distal radius fractures treated at Rangaraya Medical College, Kakinada between October 2013 to September 2015. All cases were closed fractures. All cases were followed up periodically during the period 2013 to 2015. In this series, 4(13.3%) patients were between 21-30 years, 10(33.33%) between 31-40 years, 13(36.6%) between 41-50 years, 5(16.66%) between 51-60 yrs. Out of 30 patients, 23 (76.6%) were male and 7 (23.3%) were females showing a male preponderance. Right side (dominant wrist) was involved in 18 (60%) patients and the left side involved in 12 (40%) patients. Most common mode of injury is road traffic accidents (63.33%) while fall on out stretched hand is only 36.66% In present study, the most commonly injured are manual labourers (76.66%). Surgery was done between 2-6 days from the day of injury in 29 (96.67%) patients as an elective procedure. Surgery was delayed up to 10th day in 1(3.33%) patient who had co-morbidities (hypertension and diabetes). In the present study, 18 (60%) patients had union within 2-3 months and 12 (40%) patients had union in 3-4 months There were no cases of delayed union or non-union. In present study, 27 (90%) patients had dorsiflexion within the normal functional range (minimum 45°), 29 (96.66%) had palmar flexion within the normal functional range (minimum 30°), 24 (96.66%) had pronation within the normal functional range (minimum 50°), 26 (86.66%) had supination within the normal functional range (minimum 50°), 20 (66.66%) had radial deviation within the normal functional range (minimum 15°), and all patients had ulnar deviation within the normal functional range (minimum 15°). 29 (96.66%) patients had grip strength more than 60% compared to the opposite side. 1(3.33%) had significant loss of grip strength (>60% compared to the opposite side). 7 patients had pain in the distal radioulnar joint. None patients had stiffness of the wrist. 1 patient (3.33%) had a superficial wound infection and two (6.66%) patients had pin tract infection. None of the patients had median nerve injury or arthritic changes as described by Knirk and Jupiter. There were no intraoperative complications. The study had 16.66% excellent, 80% good, 3.33% fair, and 0% poor result.

CONCLUSIONS

Kirschner wire fixation is a simple and reliable and effective method for maintenance of reduction in distal radius fractures especially in young adults. Unstable distal radius fractures, which may have a tendency to redisplace, plaster, pinning is a relatively effective method of fixation for reducible extra-articular fractures, simple intra-articular fractures that are nondisplaced, and in patients with good bone quality for restoration of preinjury anatomical alignment and there by the functional outcome in the management of distal radius fractures and allows early rehabilitation without jeopardising the fracture alignment. The functional end results have a direct relationship with the anatomical end results particularly in young adults though sometimes good functional results can be obtained even when anatomical results are poor due to innate mobility of wrist joint in elderly people. Pinning demonstrates good reproducible outcomes with minimal risk in appropriately selected fracture patterns. This technique can provide adequate fracture stability and soft tissue and vascular preservation in addition to minimal patient morbidity, which may facilitate a more rapid return to function compared with more invasive methods of treatment.

KEYWORDS

Radius Fractures C26.088.268.556, Fracture Fixation, Internal E04.555.300.300, Arthritis C05.550.114.

HOW TO CITE THIS ARTICLE: Kumar KL, Mukherjee GS, Manikumar CJ, et al. A study on fracture fixation of distal end of radius by percutaneous pinning. J. Evid. Based Med. Healthc. 2016; 3(60), 3256-3261. DOI: 10.18410/jebmh/2016/705

INTRODUCTION: Fractures of the distal radius represent one sixth of all fractures treated in emergency department^[1], closed reduction and cast immobilisation has been the mainstay of treatment of these fractures, but invariably, it results in malunion, poor functional, and cosmetic outcome.^[2] Restoration and maintenance of anatomy correlates well with function. The residual deformity of the wrist as a result of malunion is unsightly. It adversely affects wrist motion and hand function by interfering with the mechanical advantage of the extrinsic hand musculature.^[3,4,5] In many cases, there is weakness of handgrip and return to preinjury activity level becomes

*Financial or Other, Competing Interest: None.
Submission 01-07-2016, Peer Review 11-07-2016,
Acceptance 22-07-2016, Published 28-07-2016.*

Corresponding Author:

Dr. Manikumar C. J.,

Assistant Professor,

Department of Orthopaedics, Rangaraya Medical College,

Kakinada, Andhra Pradesh.

E-mail: manikumarcj@gmail.com

DOI: 10.18410/jebmh/2016/705

impossible. Closed reduction and cast immobilisation often leads to collapse of the radius.^[6,7] Percutaneous K-wire fixation provides additional stability and is one of the earliest forms of internal fixation.^[8,9,10] Depalma described ulno-radial pinning drilled at 45° angle 4 cm proximal to ulnar styloid. Kapandji.^[11] described double intrafocal pinning into the fracture surface and Rayhack described ulno-radial pinning with fixation of distal radio-ulnar joint.^[12] Bridging external fixators and ligamentotaxis indirectly reduce the fracture.^[13,14] Ruch et al and many others described open reduction and internal fixation of distal radius fracture.^[15] Doi et al recommended it for comminuted intra-articular fractures.^[16] Most of the work done with percutaneous pinning emphasises that there is significant residual stiffness of the hand and wrist.^[17,18] The acute palmar flexed position of the wrist during the postoperative immobilisation period was blamed as the main reason for stiffness.^[19]

AIMS AND OBJECTIVES:

- To evaluate radiological and functional outcome of fractures of distal radius treated with K-wire fixation in adults.
- To correlate radiological evaluation and functional outcome.
- To study stability of K-wire fixation in distal radius fractures.

MATERIALS AND METHODS: A prospective study conducted on thirty adult patients with distal radial fractures treated at Department of Orthopaedics, Rangaraya Medical College, Kakinada, between October 2013 to September 2015.

RADIOGRAPHIC EXAMINATION: Standard radiographs in PA and lateral views were taken for confirmation of the diagnosis and also to know the type of fracture. Oblique views were also taken in a few patients who had complex comminuted fractures. The fracture fragments were analysed and involvement of radiocarpal and distal radioulnar joints were assessed and classified according to the Frykman classification. Of the cases, 6(20%) of the fractures were type I, 2(6.6%) of type II, 3(10%) of type III, 6(20%) of type IV, 8(26.6%) of type V, 5(16.6%) of type VI, no cases of type VII and VIII.

SURGICAL PROCEDURE: The procedures were performed under regional anaesthesia in all cases. After sterile preparation and draping, fracture is reduced by traction and the reduction was evaluated fluoroscopically. A 1.5 cm incision given longitudinally (If needed) beginning at the radial styloid and proceeds proximally across to the medial metaphysis and diaphysis. At least two pins (1.6 mm Kirschner wire) were inserted and adequate reduction was confirmed on AP/LAT views under image intensifier. Another 1.6 mm K-wire percutaneously 90 degrees orthogonally to these wires starting at the dorsal rim of distal radius just distal to the Lister's tubercle. The correct starting point confirmed with fluoroscopy and the wire is driven in a proximal and volar direction across the fracture site to engage the volar cortex of the radius proximal to the fracture. Additional wires were passed as necessary to secure additional fracture fragments. The wires were bent and cut leaving them superficial to the skin. The radial styloid incision was closed with interrupted absorbable sutures. A below elbow POP slab was applied. The pins were removed between 4 to 6 weeks. Postoperative pain and inflammation were managed using anti-inflammatory drugs, diclofenac sodium 50 mg twice daily, and serratiopeptidase. All patients were given oral ceftriaxone 200 mg twice a day for 5 days. Patients were asked to perform active finger movements from day one. Immediate postoperative check x-rays were taken in both PA and lateral views. The reduction of the fracture was confirmed and any displacements were noted. Patients were discharged after the 5th postoperative day and advised active exercises. On followup at 2nd, 4th, 6th weeks and, 6th, 12th, 18th months, the fracture union was assessed clinically by absence of tenderness and radiologically by bridging callus formation. Below elbow slab was removed by 4 wks. and patient is advised for active movement of wrist. Then, K wires were

removed without anaesthesia on outpatient basis by 4-6 wks. The patients were advised to defer lifting heavy weights for further 4 to 6 weeks. After discharge, all patients were reviewed weekly for the first 6 weeks. Patients were assessed subjectively for pain at the fracture site, clinically for tenderness, loosening of the pins, and any signs of infection. Pronation and supination of the forearm and active movement of the elbow and shoulder were advised throughout the period of healing. After the 6th week, physiotherapy was initiated. The range of wrist movements was recorded and any deformity was assessed.

RADIOGRAPHIC ASSESSMENT: Check x-rays were taken at 12 weeks to assess consolidation or collapse at the fracture site and to note any displacement. The fracture was considered united when clinically there was no tenderness, subjective complaints, and radiologically when the fracture line was not visible. Malunion was defined as more than 5 mm radial shortening, more than 15° of volar tilt or more than 10° dorsal tilt, and more than 4 mm of radial shift. 60 arthritic changes were graded according to the system described by Knirk and Jupiter (Fig-1). Regular followup was done at an interval of 6 weeks, 6 months, 12 months, and 18 months. The results were assessed at 3 months after the procedures using the DASH score.

Inclusion Criteria:

1. Both males and females.
2. Compound fractures type I,II.
3. Simple intra-articular fractures.
4. Metaphyseal instability.
5. Age group 20-60 yrs.
6. AO-OTA classification 23A and B fractures included.

Exclusion Criteria:

1. Shear type fractures (Volar and dorsal Barton).
2. Compound fractures, type III.
3. Fractures with bone loss.
4. AO-OTA classification 23C fractures.

RESULTS: The present study consists of 30 cases of distal radius fractures treated at Rangaraya Medical College, Kakinada between October 2013 to September 2015. All cases were closed fractures. All cases were followed up periodically during the period 2013 to 2015. In this series, 4(13.3%) patients were between 21-30 years, 10(33.33%) between 31-40 years, 13 (36.6%) between 41-50 years, and 5(16.66%) between 51-60 yrs. Out of 30 patients, 23 (76.6%) were male and 7 (23.3%) were females showing a male preponderance (Fig-2). Right side (dominant wrist) was involved in 18 (60%) patients and the left side involved in 12 (40%) patients (Fig-3). Most common mode of injury is road traffic accidents (63.33%) while fall on out stretched hand is only 36.66%. In present study, the most commonly injured are manual labourers (76.66%) (Fig-4). Surgery was done between 2-6 days from the day of injury in 29 (96.67%) patients as an elective procedure. Surgery was delayed up to 10th day in 1(3.33%) patient who had comorbidities (hypertension and diabetes) (Fig-7). In the present study, 18 (60%) patients had union within 2-3 months and 12 (40%) patients had union in 3-4 months. There were no cases of delayed union or non-union (Fig-8).

In present study, 27 (90 %) patients had dorsiflexion within the normal functional range (minimum 45°), 29 (96.66%) had palmar flexion within the normal functional range (minimum 30°), 24 (96.66%) had pronation within the normal functional range (minimum 50°), 26 (86.66%) had supination within the normal functional range (minimum 50°), 20 (66.66%) had radial deviation within the normal functional range (minimum 15°), and all patients had ulnar deviation within the normal functional range (minimum 15°) (Fig-9 and 10). Twenty nine (96.66%) patients had grip strength more than 60% compared to the opposite side. 1(3.33%) had significant loss of grip strength (>60% compared to the opposite side). 7 patients had pain in the distal radio-ulnar joint. None patients had stiffness of the wrist. 1 patient (3.33%) had a superficial wound infection and two (6.66%) patients had pin-tract infection. None of the patients had median nerve injury or arthritic changes as described by Knirk and Jupiter. There were no intraoperative complications. The study had 16.66% excellent, 80% good, 3.33% fair, and 0% poor result. (Fig-12).

Grade	Findings
0	None
1	Slight joint space narrowing
2	Marked joint space narrowing, formation of osteophytes
3	Bone on bone, formation of osteophytes and cysts

Figure 1: Grading of arthritis: Knirk and Jupiter

Sex	No. of Cases	Percentage
Male	23	76.6
Female	7	23.3

Figure 2: Sex Incidence

Side	No. of Cases	Percentage
Right	18	60
Left	12	40

Figure 3: Side of Involvement

Mode of Injury	No. of Cases	Percentage
Road Traffic Accident	19	63.33
Fall on Outstretched Hand	11	36.66

Figure 4: Mode of Injury

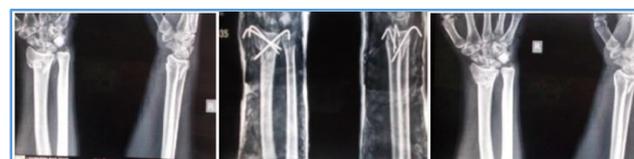


Figure 5: X-Ray Result



Figure 6: Surgical Result

Duration	No. of cases	Percentage
2-6 Days	29	96.67
7-10 Days	1	3.33

Figure 7: Duration of Operation from Date of Injury

Time of Union	No. of cases	Percentage
2-3 Months	18	60
3-4 Months	12	40

Figure 8: Duration of Fracture Union

Time of Union	No. of cases	Percentage
Prominent Ulnar Styloid	2	6.66
Radial Deviation	4	13.3
Dinner Fork Deformity	1	3.3
Total	7	23.33

Figure 9: Deformity

Movement (Within normal functional range)	No. of cases	Percentage
Dorsiflexion (Min. 45°)	27	90
Palmer Flexion (30°)	29	96.66
Pronation (50°)	28	93.33
Supination (50°)	26	86.66
Radial Deviation (15°)	20	66.66
Ulnar Deviation (15°)	-	-

Figure 10: Range of Motion

Complications	No. of cases	Percentage
Superficial infection	1	3.3
Pin Tract Infection	2	6.66
Malunion		
Total	3	10

Figure 11: Complications

Results	No. of cases	Percentage
Excellent	5	16.66
Good	24	80
Fair	1	3.33
Poor	0	0

Figure 12: Evaluation of Results

DISCUSSION: Percutaneous pinning with K-wires was first recommended by Green (1975) as a simple and inexpensive procedure.^[20] Green reported an 86% satisfactory result with this technique used in the treatment of 75 patients with severely comminuted intra-articular fractures.^[21] Excellent results were reported by Stein and Katz (1975) in their comparative study, which involved percutaneous pinning of distal radius fractures and casting alone. They confirmed decrease in the radial shortening maintenance of the normal volar tilt and superior range of motion with percutaneous pinning.^[22] Intra-focal pinning of distal radius fractures was described first by Kapandji.^[23,24] It is indicated in unstable distal radius fracture without significant intra-articular displacement. Two K-wires are inserted directly into the fracture site dorsally parallel to the fracture line. The pins are then directed obliquely and proximally to buttress the distal fragment and to improve the palmar tilt and radial inclination of the articular surface. Clancey 18 (1984), Jenkins et al (1987) have observed that methods that maintain the reduction by additional fixation help to improve results.^[25] This conclusion has been supported by recent studies, with Rodriguez Merchan (1997) demonstrating improved radiographic and functional outcomes in a group of patients between 45 and 65 years of age with a cross-wire percutaneous technique.^[26] An extra-focal K-wire technique (two parallel styloid pins) described by Rosati and colleagues (2006) demonstrated good radiographic and functional outcomes without tendon or nerve injury.^[27]

The average age in present study is comparable to the studies of Abhishek K Das et al (2011) and Manandhar RR et al (2011) who had an average age of 41.4 Years, 42.72 Years respectively.(table1).The right side (dominant wrist) was involved in 60% of the cases in our study. Chin-En Chen et al (2008) had increased involvement of the left wrist in their series. But, the series of Abhishek K Das et al (2011) and Manandhar RR et al (2011) had increased involvement of the right wrist, which was also the same in present series. Right side is more common maybe because of more number of right-handed persons using right hand first for protecting themselves while fall on the ground.

COMPLICATIONS: Manandhar RR et al (2011) reported that two patients developed superficial pin-site infection, which resolved with a course of antibiotics.^[28] According to Abhishek K Das et al pin loosening was encountered in 13 cases.^[20] Pin-tract infection, malunion, joint stiffness, reduced grip strength, and paraesthesia in the distribution of superficial radial nerve were the other complications observed in our study as with the above studies. Reflex sympathetic dystrophy was not encountered in our study. Posttraumatic arthritis of wrist, subluxation of distal radio-

ulnar joint, and penetration of vessel were not seen (Fig-11). Uzzaman KS et al reported one pin-tract infection (5%) out of 20 cases.^[29] In our study, three patients had infection and subsided by antibiotic administration. Restriction of movements was seen in one case. Four patients had radial deviation, one patient had prominent ulnar styloid, and one patient had dinner fork deformity. None had decreased grip strength, neuropathy, delayed union, tendon injury, breakage, or pull out of K-wire. Most of the patients initially complained of pain after 4 weeks and 6 weeks when pop slab and K-wires removed respectively. At this time, they were in the uncomfortable range in the Visual Analogue Pain Scale (VAS). It was observed that with physiotherapy and as time progressed there was significant relief from pain and improved to none or no distress in the visual analogue scale by the end of 3-4 months in all.

CONCLUSION: Kirschner wire fixation is a simple and reliable and effective method for maintenance of reduction in distal radius fractures especially in young adults. Unstable distal radius fractures, which may have a tendency to redisplace, plaster, pinning is a relatively effective method of fixation for reducible extra-articular fractures, simple intra-articular fractures that are non-displaced and in patients with good bone quality for restoration of pre-injury anatomical alignment and there by the functional outcome in the management of distal radius fractures and allows early rehabilitation without jeopardizing the fracture alignment. The functional end results have a direct relationship with the anatomical end results particularly in young adults though sometimes good functional results can be obtained even when anatomical results are poor due to innate mobility of wrist joint in elderly people. Pinning demonstrates good reproducible outcomes with minimal risk in appropriately selected fracture patterns. This technique can provide adequate fracture stability and soft tissue and vascular preservation in addition to minimal patient morbidity, which may facilitate a more rapid return to function compared with more invasive methods of treatment.

REFERENCES

1. Bucholz RW, Heckman JD, Brown CM. Rockwood and Green's fractures in adults. Vol. 1. Philadelphia: Lippincott Williams and Wilkins 2006:p. 910.
2. Gofton W, Liew A. Distal radius fractures: nonoperative and percutaneous pinning treatment options. Orthop Clin North Am 2007;38(2):175-185.
3. Fernandez DL, Jupiter JB. Fractures of the distal radius: a practical approach to management. New York NY: Springer-Verlag 1996.
4. Fernandez DL. Correction of posttraumatic wrist deformity in adults by osteotomy, bone grafting, and internal fixation. J Bone Joint Surg Am 1982;64(8):1164-1178.
5. Fernandez DL. Radial osteotomy and Bowers arthroplasty for malunited fractures of the distal end of radius. J Bone Joint Surg Am 1988;70(10):1538-1551.

6. Slagel BE, Luenam S, Pichora DR. Management of posttraumatic malunion of fractures of distal radius. *Orthop Clin North Am* 2007;38(2):203-216.
7. Arora J, Kapoor H, Malik A, et al. Closed reduction and plaster cast immobilisation vs external fixation in comminuted intra-articular fractures of distal radius. *Indian J Orthop* 2004;38(2):113-117.
8. Castaing J. Recent fractures of the inferior extremity of the radius in the adult. *Rev Chir Orthop French Reparatrice Appar Mot* 1964;50:582-696.
9. Mah ET, Atkinson RN. Percutaneous Kirschner wire stabilisation following closed reduction of Colles fracture. *J Hand Surg Br* 1992;17(1):55-62.
10. DePalma AF. Comminuted fractures of the distal end of the radius treated by ulnar pinning. *J Bone Joint Surg Am* 1952;24A(3):651-62.
11. Kapandji A. Intra-focal pinning of fractures of the distal end of the radius 10 years later. *Ann Chir Main* 1987;6(1):57-63.
12. Rayhack JM, Langworthy JN, Belsole RJ. Transulnar percutaneous pinning of displaced distal radial fractures: a preliminary report. *J Orthop Trauma* 1989;3(2):107-114.
13. Edwards GS. Intra-articular fractures of the distal part of the radius treated with the small AO external fixators. *J Bone Joint Surg Am* 1991;73(8):1241-1250.
14. Nagi ON, Dhillon MS, Aggarwal S, et al. External fixators for intra-articular distal radius fractures. *Indian J Orthop* 2004;38:19-22.
15. Ruch DS, Ginn TA. Open reduction and internal fixation of distal radius fractures. *Op Tech Orthop* 2000;13:138-143.
16. Doi K, Hattori Y, Otsuka K, et al. Intra-articular fractures of the distal aspect of the radius: arthroscopically-assisted reduction compared with open reduction and internal fixation. *J Bone Joint Surg Am* 1999;81(8):1093-1110.
17. Field J, Atkins RM. Algodystrophy is an early feature after Colles fracture. What are the implications? *J Hand Surg Br* 1997;22(2):178-182.
18. Atkins RM, Duckworth T, Kanis JA. Features of algodystrophy after Colles fracture. *J Bone Joint Surg Br* 1990;72(1):105-110.
19. Rajan S, Jain S, Ray A, et al. Radiological and functional outcome in extra-articular fractures of lower end radius treated conservatively with respect to its position of immobilisation. *Indian J Orthop* 2008;42(2):201-207.
20. Das AK, Sundaram N, Prasad TG, et al. Percutaneous pinning for non-comminuted extra-articular fractures of distal radius. *Indian J orthop* 2011;45(5):422-426.
21. Green DP. Pins and plaster treatment of comminuted fractures of the distal end of radius. *J Bone Joint Surg Am* 1975;57(3):304-310.
22. Stein AH, Katz SF. Stabilisation of comminuted fractures of the distal radius: percutaneous pinning. *Clinical Orthopaedics* 1975;108(108):174-181.
23. Kapandji A. Internal fixation by double intrafocal plate: functional outcome treatment of non-articular fractures of the lower end of radius. *Ann Chir* 1976;30(11-12):903-908.
24. Kapandji A. Intra-focal pinning of fractures of the lower end of the radius. Ten years after. *Ann Chir Main* 1987;6:57-63.
25. Clancey GJ. Percutaneous Kirschner wire fixation of Colles fracture. A prospective study of thirty cases. *J Bone Joint surg* 1984;66(7):1008-1014.
26. Rodriguez-Merchan EC. Plaster cast versus percutaneous pin fixation for comminuted fractures of the distal radius in patients between 46 and 65 years of age. *J Orthop Trauma* 1997;11(3):212-241.
27. Rosati M, Bertagnini S, Digrandi G, et al. percutaneous pinning for fractures of the distal radius. *Acta Orthop Belg* 2006;72(2):138-146.
28. Manandhar RR, Lakhey S, Pandey BK, et al. Displaced Colles fractures: functional outcome following closed reduction and stabilisation with percutaneous K-wires. *Nepal Orthopaedic Association Journal* 2011;2(1):14-20.
29. Uzzaman KS, Awal KA, Alam MK. Closed reduction and percutaneous Kirschner wire fixation combined with plaster cast immobilisation in the treatment of Colles fracture-a prospective randomised comparative study. *J Dhaka Med Coll* 2008;17(2):98-105.