RESEARCH ARTICLE

Application of Rikkli and Regazzoni three-column theory in distal radius intraarticular fractures and its functional and radiological assessment

Muhammad Asad Iqbal Khan,[1] Syed Faraz Ul Hassan Shah,[2] Ahmed Humayoun Sarfraz,[3] Umar Hayat,[4] Hafiz Ahmed Fayyaz Bajwa[5]

Abstract

Objective: To determent the effectiveness of Rikli and Regazzoni three-column theory in treating intra-articular fractures of the distal radius with T-plate and K-wire in terms of functional outcome and fracture union.

Method: The cross-sectional study was conducted at the Department of Orthopaedic Surgery and Traumatology, King Edward University, Mayo Hospital, Lahore, Pakistan, from June 2013 to March 2017, and comprised patients aged 15-60 years having closed intraarticular fracture of the distal radius <1 month older. The subjects were divided into two group A, managed by percutaneous K-wire fixation, and group B, managed with open reduction and internal fixation using T-plates. Wound infection, supination and pronation, flexion and extension at the wrist joint, bone union and functionality were observed. All patients were followed up with intervals for 12 months in the out-patient department, and wound infection and supination and pronation of the forearm were observed clinically. Union was observed using the standard criterion, and function was evaluated using the Disabilities of Arm, Shoulder and Hand score. Data was analysed using SPSS 20.

Results: Of the 60 patients, there were 30(50%) with mean age 48.83±11.11 years in group A, and 30(50%) with mean age 49.87±13.45 years in group B. Overall, there were 49(81.7%) males and 11(18.3%) females. There were 33(55%) cases with right side involvement, and 27(45%) had the left side involved. Functionality imprived significantly in both groups ($p<0.05$). Union was observed in all cases in both groups, while the mean duration in group A was 9.21±1.74 weeks, and in group B it was 9.87±2.14 weeks.

Conclusion: Restoration of the three columns of distal radius could either be fixed with T-plates and K-wires because there was no significant difference between the two groups.

Keywords: Rikli, Regazzoni, Three-column theory, Distal radius intraarticular fractures, K-wires, ORIF.

(JPMA 72: 1921; 2022) **DOI: https://doi.org/10.47391/JPMA.0170**

Introduction

The specific treatment of distal radius fractures has transformed entirely from nearly extensive use of the plaster of Paris (POP) application to a multitude of vastly sophisticated surgical interventions.[1,2] Emergency visits comprise 2.5% of distal radius injuries.[1,3,4] Distal radius fractures were present in 17% of adults in a bimodal scattering of distal radial fractures comprising a set of young people who endured high-strength injury to the upper limbs and an elder cluster which suffered traumatic and osteoporotic fractures equally.[5] The majority of fractures in the elder group are extraarticular, but intraarticular fractures are more prevalent in young patients.[6] There is also dissimilarity in the mode of trauma in the elderly who undergo fall, and the young with road traffic accidents (RTAs) and sports injuries.[7,8]

Department of Orthopedic Surgery, [1]Indus Hospital, Lahore, [2,3,5]King Edward Medical University, Mayo Hospital, Lahore, [4]Mian Munshi Hospital, Lahore, Pakistan.

Correspondence: Muhammad Asad Iqbal Khan.

Email: asadiqbalkhan@gmail.com

In the elderly, causative elements for distal radius are extensively examined. Diminished bone mineral density (BMD), female gender, ethnicity, genetics, and untimely menopause have been shown as causative features for wrist fractures, and at any stage of the treatment, complications related to the fracture of distal radius can take place, and the incidence is up to 27% of all such fractures.[9] An orthopaedic surgeon must be attentive to the likely problems, which include nerve damage, stiffness, infection arthrosis, malunion, non-union, pain, soft-tissue, neuro-vascular, and bony complications, comprising extensor tendon or flexor tendon damage, carpal tunnel syndrome, complex-local pain-syndrome, and implant failure.

The three-column principle using Rikkli and Reggazzoni[10] for distal radial intraarticular fractures explains the wrist as a biomechanical construct. It splits the wrist joint into three distinct columns, including radial, ulnar and intermediate parts. According to the principle, the treatment goal should be the anatomical reduction of the fracture, which will align the wrist, giving the patient an improved wrist strength for daily activities. To permit

structural alignment of the radiocarpal and the radioulnar joint and to achieve normal function, displaced articular fractures necessitate sound reduction and fixation.[11] Several treatment procedures comprised closed manipulation and POP, percutaneous K-wire insertion, and open reduction and internal fixation (ORIF_ with T-plates.[12-18]

For fractures of the distal radius, intraarticular treatment principles must be the same as any other joint injury. All displaced joint fractures require manipulation for functional restoration of radiocarpal and the radioulnar joints alike.

The current study was planned to evaluate the effectiveness of Rikli and Regazzoni[10] three-column theory in treating intra-articular fracture of the distal radius with T-plate and K-wire in terms of the functional outcome and fracture union.

Patients and Methods

The cross-sectional study was conducted at the Department of Orthopaedic Surgery and Traumatology, King Edward Medical University (KEMU), Mayo Hospital, Lahore, Pakistan, from June 2013 to March 2017. After approval from the institutional review board of KEMU, The sample size of 60 patients, was estimated by using 1% level of significance, 95% power of test with expected percentage of k wires as 19%[19] and t plates as 70%.[20] The sample was raised using consecutive sampling technique. Those included were patients of either gender aged 15-60 years having closed intraarticular fracture of the distal radius <1 month old diagnosed on the basis of history and clinical examination. Patients presenting with pathological fracture, both bone fracture with compartment syndrome needing fasciotomy, recognised hereditary bone disorder, associated injury, like vascular injury, head trauma and infection, were excluded.

After taking informed written consent from all the patients, they were divided into two groups. All patients were assessed for treatment options by a hand surgeon with >10 years of experience. All cases were operated either by the hand surgeon or by researchers under the supervision of the hand surgeon. Group A was managed by percutaneous K-wire fixation, while group B was given ORIF using T-plates. Pre-operative third-generation cephalosporin (ceftriaxone) 1gm was given half-an-hour before the surgery and two doses were administered postoperatively. The postoperative above-elbow POP cast was given in both groups for two weeks. Radius was operated through a volar Henry incision. The primary surgeon and another consultant with >5 years of experience assessed the wound infection, supination and pronation, flexion, and extension at the wrist joint, union, and upper limb function. The surgical wound was inspected on the second postop day, and the patient discharge status was contingent on the wound status. All patients were followed up in the outpatient department (OPD) at 2nd, 6th, and 12th weeks and then at 6, 9 and 12 months. Wound infection and supination and pronation of the forearm were observed clinically. Union was observed using Hammer et al. criteria,[21] and upper-limb function was evaluated using the Disabilities of Arm, Shoulder and Hand (DASH) score.[22]

Data was analysed using SPSS 20. Quantitative variables, like age, were presented as mean and standard deviation. Qualitative variables, like gender, appearance and outcome, were expressed as frequencies and percentages. The Kolmogorov-Smirnov Z test was applied to the ages and DASH score to test the normality of data distribution. The sample t-test was applied for normally distributed data, and the Mann-Whitney U test was applied for non-normally distributed data. The Chi-square test and odds ratio (OR) with 95% confidence interval (CI) was calculated to see the effectiveness of the two modalities of treatment. $P \leq 0.05$ was taken as significant.

Results

Of the 60 patients, there were 30(50%) with mean age 48.83±11.11 years in group A, and 30(50%) with mean age 49.87±13.45 years in group B. Overall, there were 49(81.7%) males and 11(18.3%) females. There were 33(55%) cases with right side involvement, and 27(45%) had the left side involved (Table-1).

Data related to age and DASH scores at 6 and 12 weeks was normally distributed, while the rest of the variables were not normally distributed.

Functionality imprived significantly in both groups ($p<0.05$). After 12 months, no restriction in supination and pronation was seen in 29(96.67%) patients in group A, and 24(80%) patients in group B. Mild restriction in supination and pronation was observed in 1(3.33%) patient in group

Table-1: Demographic data.

Variables	Group A (n=30)	Group B (n=30)	N=60	p-value
Gender of the patients	22 (73.33%)	27 (90%)	49 (81.7%)	0.095
• Male	08 (26.67%)	03 (10%)	11 (18.3%)	
• Female				
Side involved	18 (60%)	15 (50%)	33 (55%)	0.59
• Right side	12 (40%)	15 (50%)	27 (45%)	
• Left side				
Mean age of the patients (years)	48.83±11.11	49.87±13.45	49.35 ± 12.24	0.747

Table-2: Comparison of wound status and flexion/extension in study groups.

Wound		Study Groups		p-value
		Group A	Group B	
At 2nd weeks	Satisfactory	20 (66.67%)	26 (86.67%)	0.197
	Healed	10 (33.33%)	04 (13.33%)	
At 6th weeks	Satisfactory	11 (36.67%)	17(56.67%)	0.121
	Healed	19 (63.33%)	13 (43.33%)	
At 12th weeks	Satisfactory	05 (16.67%)	09 (30%)	0.22
	Healed	25 (83.33%)	21 (70%)	
Flexion / extension				
At 2nd weeks	Mild restriction	0(0%)	1(3.33%)	0.601
	Moderate restriction	2(6.67%)	2(6.67%)	
	Severe restriction	28(93.33%)	27(90%)	
At 6th weeks	Mild restriction	2(6.67%)	0(0%)	0.195
	Moderate restriction	10(33.33%)	15(50%)	
	Severe restriction	18(60%)	15(50%)	
At 12th weeks	Mild restriction	8(26.67%)	4(13.33%)	0.035
	Moderate restriction	13(43.33%)	19(63.33%)	
	Severe restriction	9(30%)	7(23.33%)	
At 6th month	No restriction	2(6.67%)	0(0%)	0.268
	Mild restriction	19(63.33%)	23(76.67%)	
	Moderate restriction	9(30%)	7(23.33%)	
At 9th months	No restriction	9(30%)	6(20%)	0.549
	Mild restriction	18(60%)	22(73.33%)	
	Moderate restriction	3(10%)	2(6.67%)	
At 12th months	No restriction	27(90%)	21(70%)	0.053
	Mild restriction	3(10%)	9(30%)	
Supination/pronation				
At 2 weeks	Moderate restriction	4(13.33%)	3(10%)	0.688
	Severe restriction	26(86.67%)	27(90%)	
At 6 weeks	Mild restriction	2(6.67%)	0(0%)	0.331
	Moderate restriction	19(63.33%)	20(66.67%)	
	Severe restriction	9(30%)	11(36.67%)	
At 12 weeks	Mild restriction	8(26.67%)	9(30%)	0.746
	Moderate restriction	17(56.67%)	18(60%)	
	Severe restriction	5(16.67%)	3(10%)	
At 6 months	No restriction	2(6.67%)	1(3.33%)	0.556
	Mild restriction	21(70%)	25(83.33%)	
	Moderate restriction	6(20%)	4(13.33%)	
	Severe restriction	1(3.33%)	0(0%)	
At 9 months	No restriction	10(33.33%)	6(20%)	0.275
	Mild restriction	19(63.33%)	24(80%)	
	Severe restriction	1(3.33%)	0(0%)	
At 12 months	No restriction	29 (96.67%)	24 (80%)	0.044
	Mild restriction	1 (3.33%)	6 (20%)	

A and 6(20.0%) patients in group B. There was no significant difference in supination and pronation in both groups during the follow-up except after 12 months when higher effects were noted in group A (p=0.044) (Table-2).

The mean duration of the union in group A was 9.21±1.74 weeks and in the group, B was 9.87±2.14 weeks (p-value >0.05). Functional outcome improved significantly at 24th week (p<0.008), but there was no significant inter-group difference at other follow-up points (Table-3).

Table-3: Comparison of the Disabilities of Arm, Shoulder and Hand (DASH) score in the study groups.

DASH score	Groups	Mean	S.D	Median	IQR	p-value
2nd weeks	Group A	81.95	3.78	81.6	2.7	0.347a
	Group B	81.18	5.28	80.95	4.8	
	Total	81.56	4.57			
6th weeks	Group A	66.53	13.83	70.25	16.5	0.236b
	Group B	61.97	15.64	62.2	24.5	
	Total	64.25	14.82			
12th weeks	Group A	55.26	13.81	58	18.2	0.177b
	Group B	50.42	13.61	50.7	17.5	
	Total	52.84	13.81			
6th months	Group A	46.18	14.23	48.5	26.1	0.008a
	Group B	35.81	8.81	32.5	11.3	
	Total	41.00	12.85			
9th month	Group A	32.13	12.03	33.75	21.0	0.112a
	Group B	25.87	8.03	21.9	9.5	
	Total	29.00	10.62			
12th months	Group A	16.33	5.59	17.4	11.1	0.180a
	Group B	14.26	5.51	12.1	6.3	
	Total	15.30	5.60			

*Group A: Percutaneous K-wire fixation, Group B: Internal fixation using T-plates.
*a=Mann Whitney-U test was applied, b=t-test was applied.

Discussion

There was no difference in terms of the union in both groups until the last follow-up in the current study. The mean duration of union in group A was 9.21±1.74 weeks and in group B it was 9.87±2.14 weeks (Figure-1 & 2). Phadnis et al.[23] reported overall mean time to fracture union was 8.4 weeks (range: 6-28 weeks). Khan et. al.[24] reported mean DSH score in distal radius fracture at 6-months to be 17.2±8.8 (range: 4-40). Quadlbauer et al.[25] reported mean quick DASH score in distal radius fracture at last follow-up to be 11.1±13.8. In the current study, the mean DASH score till the last follow-up was 16.33±5.59 in patients treated with T-plate. Jacob et al.[26] treated distal radius fracture with percutaneous K-wire and reported mean Mayo's score of 85.66±7.07 (range: 75-100). In the current study, the mean DASH score in K-wire fixation was 14.26±5.51.

In the upper extremity, fractures of the distal radius are the most commonly seen injuries. In contrast to the more prevalent, lower energy, extraarticular fractures, intraarticular distal radius fractures signify a problematic injury that is linked with significant morbidity. Generally displaced, comminuted, intraarticular fractures have a poor prognosis. Difficulties in reinstating the wrist joint are the prime reason for poor results.[27]

Distal radius fractures are managed in considerable numbers.[28] Although distal radius fractures are seen most frequently in females aged >40 years, young adults make

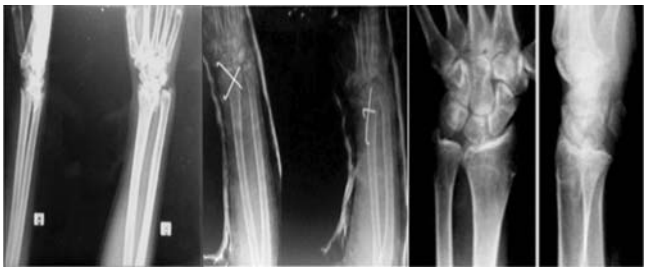

Figure-1: Radiographs of a patient with distal radius fractures treated with K-wire, till last follow-up after the removal of the K-wire after radiological union.

Figure-2: Radiographs of a patient with distal radius fractures treated with T-plate, showing radiological union till last followup.

a substantial portion of the cases. In females, the frequency rises sharply after the age of 40 from approximately 36.8/10000 to 115/10000 at the age of 70. The sharpest increase in incidence arises in elderly females. It has been related to oestrogen withdrawal and reduced bone density.[29]

A study reported mean age of patients as 58.3 years (range 20-80 years), with 20(23.5%) males and 65(76.5%) females.[30] One more study described a higher female ratio of 5:1.[31] A recent study mean age of 43 years (range: 23-53 years).[32] A study reported equal gender distribution with mean age 51 years.[31] In the current study, the overall mean age was 49.35 years, with a higher male-to-female ratio. The gender distribution is comparable, while mean age is lower compared to earlier studies,[30,32] but age distribution waas reported in a study.[33]

More aggressive treatment regimens are usually required to reestablish the wrist joint anatomically. When applicable reduction is attained, renovation of discount with fixation via pins and plaster or outside fixation is challenging because of the innate unpredictability of the wrist damage and the propensity for articular fragments to settle after stress relaxation of the tension soft tissue casing. Also, it is not unusual for cases with displaced, intraarticular distal radius fractures to have associated, identical side, higher extremity injuries, which makes their management difficult.[34]

ORIF techniques have been set up to treat the comminuted intraarticular distal radius fractures that can not be anatomically reestablished and sustained through external manipulation and ligamentotaxis.[35] Open techniques restore widespread joint composition and wrist joint congruency by means of permitting direct reduction and rigid inner fixation of intraarticular parts. Early convalescence can be commenced with the goal of higher functional outcome by means of making a more regular construct through internal fixation.[36] Anatomic discount, stable fixation, and early rehabilitation of the hand and wrist are the top goals for managing complicated intraarticular distal radius fractures. The mainstay of remedy for these intricate accidents is external fixation augmented with the aid of K-wires to boom fracture fragment stability.[37]

ORIF outcomes after fracture displacement in 20 patients aged >60 years were studied. Volar and dorsal procedures were both used with outstanding functional outcomes in 18 and superb radiographic results in 19 patients; the complication rate was 15%, containing a tendon rupture. ORIF was considered an expected intervention after unsuccessful closed management of distal radius fractures.[38] In another trial, functional results of 166 patients managed with non-locking volar plates had 81% good or very good, with equally promising radiological outcomes. Initially, wrist range of motion (ROM) was permitted, and the use of a POP was advised. Patients in each set younger and those aged >60 did equally fine. The incidence of complications for each group was18%, and the complications were predominantly median nerve irritation.[39] The current study did not find such a complication rate as it focussed on DASH score, union, flexion/extension, and supination, etc., and both groups improved equally.

Both dorsal plates and K-wire and volar plate fixation procedures were studied in patients with a mean age of 71 years in whom initial closed reduction and cast immobilisation attempts were unsuccessful. Overall, 78% subjects were satisfied, and 22% were moderately happy. No fractures were displaced, and the Gartland score displayed 83% excellent and 17% good outcomes. There was 16% incidence of complications in plate fixation, and a supplementary 5% was credited to associated K-wire insertion. The study recommended both volar and dorsal ORIF as excellent stabilisation systems with a higher incidence of good and excellent results.[38] The current study also found significant results in terms of lesser DASH scores in both the groups at the last follow-up. The mean DSH score was significant till the last follow-up.

By bone grafting, radial shortening was avoided and it supported the reduced articular surface, which revealed better practical results.[40] ORIF produces a more stiff mechanical construct that allows initial mobilisation, but

due to extensive soft tissue dissection, they have been linked with higher complication rates than the closed techniques.[41]

In 1996[10] it was proposed that fractures of the distal end of the radius should be treated on the same principles as other joint fractures. To permit anatomical restoration of both the radiocarpal and the radioulnar joints of the wrist, displaced articular fractures necessitate open reduction. Stable internal fixation can be achieved with two 2.0 Arbeitsgemeinschaft für Osteosynthesefragen (AO) titanium plates positioned on each of the 'lateral' and the 'intermediate' columns of the wrist at an angle of 50-70 degrees. This offers good stability regardless of the small dimensions of the plates and permits early function.[39] A series of 20 fractures managed by this technique of internal fixation reported acceptable results in all cases.[39] The current study extended this idea and applied the concept to compare the efficacy of the Rikkli and Reggazzoni three-column concept[10] in the treatment of distal radius intraarticular fractures by applying T-plates and K-wires for fixation. Both surgical options were equally effective and could be utilised to achieve the maximum clinical and functional outcome.

Wire irritation was reported in patients with K-wire fixation, and implant removal was done in T-plate, which the current study did not consider a variable at the start.

The current study had a small sample size and it did not use other radiographic parameters, including volar tilt, radial height and inclination, which are study limitations. Further studies are needed to gather more evidence for the application of Rikli and Regazzoni's three-column theory[10] in the treatment of distal radius intraarticular fractures.

Conclusion

Good to excellent functional and satisfactory union results were found in both treatment groups for the management of distal radius fracture in maintaining the Rikli and Regazonni three-column approach without wound infection and acceptable flexion and extension as well as supination and pronation of the wrist joint.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Green DP, Rockwood CA, Bucholz RW, Heckman JD, Tornetta P. Rockwood and Green's fractures in adults: Lippincott Williams & Wilkins, 2010.
2. Hove LM. A Historical Review of the Distal Radius Fracture. In: Hove LM, Lindau T, Hølmer P, eds. Distal Radius Fractures: Current Concepts. Berlin, Heidelberg: Springer Berlin Heidelberg, 2014; pp-11-9.
3. Nellans KW, Kowalski E, Chung KC. The Epidemiology of Distal Radius Fractures. Hand Clin. 2012; 28:113-25.
4. Lalone EA, Rajgopal V, Roth J, Grewal R, MacDermid JC. A cohort study of one-year functional and radiographic outcomes following intra-articular distal radius fractures. Hand. 2014; 9:237-43.
5. Simic PM, Placzek JD. Distal radius fractures. In: Simic PM, Placzek JD, eds. Surgical treatment of orthopaedic trauma Thieme 2nd ed. New york: Thieme's publications, 2011.
6. Knirk JL, Jupiter JB. Intra-articular Fractures of the Distal End of the Radius in Young Adults. J Bone Joint Surg Am. 1987; 69:791.
7. Prasath GL, Arun R, Radhakrishnan S. Surgical Management Of Fractures Of Distal End Radius With Locking Compression Plate. Int J surg Orthopedics.2018; 4:12-9.
8. Beumer A, Adlercreutz C, Lindau TR. Early prognostic factors in distal radius fractures in a younger than osteoporotic age group: a multivariate analysis of trauma radiographs. BMC Musculoskelet Disord. 2013;14:170.
9. Kang JW PJ. Complications of Distal Radius Fracture. J Korean Orthop Assoc. 2013; 48:12-32.
10. Rikli DA, Regazzoni P. Fractures of the distal end of the radius treated by internal fixation and early function. A preliminary report of 20 cases. J Bone Joint Surg. 1996; 78:588–92.
11. Obert L, P-B Rey, Uhring J, Gasse N, Rochet S, Lepage D, et al. Fixation of distal radius fractures in adults: a review. . Orthop Traumatol Surg Res. 2013; 99:216-34.
12. Diaz-Garcia RJ, Oda T, Shauver MJ, Chung KC. A systematic review of outcomes and complications of treating unstable distal radius fractures in the elderly. J Hand Surg. 2011; 36:824-35. e2.
13. Porrino JA, Maloney E, Scherer K, Mulcahy H, Ha AS, Allan C. Fractures of the distal radius: postmanagement radiographic characterization. AJR Am J Roentgenol. 2014; 203:846-53.
14. Nandakumar S. Comprehensive study of operative management of fractures of distal end radius. J Family Med Prim Care. 2014; 3:325-32.
15. Dzaja I, Roth J. Functional outcomes and cost estimation for extraarticular and simple intra-articular distal radius fractures treated with open reduction and internal fixation versus closed reduction and percutaneous Kirschner wire fixation. Can J Surg. 2013; 56:378.
16. Grewal R, MacDermid JC, King GJ, Faber KJ. Open reduction internal fixation versus percutaneous pinning with external fixation of distal radius fractures: a prospective, randomized clinical trial. J Hand Surg. 2011; 36:1899-906.
17. Ruckenstuhl P, Bernhardt GA, Sadoghi P, Glehr M, Holzer LA, Leithner A, et al. Quality of life after volar locked plating: a 10-year follow-up study of patients with intra-articular distal radius fractures. BMC Musculoskelet Disord. 2014;15:250.
18. Bartl C, Stengel D, Bruckner T, Rossion I, Luntz S, Seiler C, et al. Open reduction and internal fixation versus casting for highly comminuted and intra-articular fractures of the distal radius (ORCHID): protocol for a randomized clinical multi-centre trial. Trials. 2011; 12:84.
19. McFadyen I, Field J, McCann P, Ward J, Nicol S, Curwen C. Should unstable extra-articular distal radial fractures be treated with fixed-angle volar-locked plates or percutaneous Kirschner wires? A prospective randomised controlled trial. Injury. 2011; 42:162-6.
20. Wilcke MK, Hammarberg H, Adolphson PY. Epidemiology and changed surgical treatment methods for fractures of the distal radius: a registry analysis of 42,583 patients in Stockholm County, Sweden, 2004–2010. Acta Orthop. 2013; 84:292-6.
21. Hammer RRR, Hammerby S, Lindholm B. Accuracy of radiologic

assessment of tibial shaft fracture union in humans. Clin Orthop. 1985; 199:233-8.
22. Fok MW, Klausmeyer MA, Fernandez DL, Orbay JL, Bergada AL. Volar plate fixation of intra-articular distal radius fractures: a retrospective study. J Wrist Surg. 2013; 2:247-54.
23. Phadnis J, Trompeter A, Gallagher K, Bradshaw L, Elliot DS, Newan KJ. Mid-term functional outcome after the internal fixation of distal radius fractures. J Orthop Surg Res.2012; 7:1-8.
24. Khan MS, Noordin S, Hashmi PM. Intra-articular distal radius fractures: Postoperative roentgenographic and functional outcomes. J Pak Med Assoc. 2016; 66:275-9.
25. Quadlbauer S, Pezzei C, Jurkowitsch J, Rosenauer R, Pichler A, Schättin S, et al. Functional and radiological outcome of distal radius fractures stabilized by volar-locking plate with a minimum follow-up of 1 year. Arch Orthop Trauma Surg. 2020; 140:843-52.
26. Jacob C, Anoop RL, Philip NT. Functional and Radiological Outcomes of Distal Radius Fractures Treated with Closed Reduction and Percutaneous Five Pin Technique-A Prospective Cohort Study. Int J Rec Tren Sci Tech. 2014; 10:430-33.
27. Ladd AL, Pliam NB. The role of bone graft and alternatives in unstable distal radius fracture treatment. Ortho Clin NA. 2001; 32:337-51.
28. Brinker M. Review of Orthopaedic Trauma. Philadelphia: WB Saunders Company, 2001; pp-277-84.
29. Bucholz R, Heckman J, Court-Brown C. Rockwood and Greens Fractures in adults. 6th ed. Philadelphia: Lippincott Williams and Wilkins, 2006; pp-910-61.
30. Hashimi IA, Rafi MS, Razi SS. Modified Kapandji wiring technique for unstable fractures of distal end of radius. J Surg Pak Int. 2008; 13:51-4.
31. Yang TY, Tsai YH, Shen SH, Huang KC. Radiographic Outcomes of Percutaneous Pinning for Displaced Extraarticular Fractures of the Distal Radius: A Time Course Study. Biomed Res Int. 2014; 2014:540874.
32. Sherchan B, Raj TKRD, Adhikari B. Functional Outcome of Displaced Extraarticular Distal Radius Fracture by Kapandji Intrafocal Fixation. Tech Hand Up Extrem Surg. 2019; 23:38-43.
33. Rubin G, Chezar A, Rinott M, Bor N, Rozen N. Treatment of intra-articular distal radius fractures by the volar intrafocal Kapandji method: a case series. Tech Hand Up Extrem Surg. 2013; 17:91-8.
34. Zanotti RM, Louis DS. Intra-articular fractures of the distal end of the radius treated with an adjustable fixator system. J Hand Surg Am. 1997; 22:428-40.
35. Swigart CR, Wolfe SW. Limited incision open techniques for distal radius fracture management. Orthop Clin NA. 2001; 32:317-27.
36. Barrie KA, Wolfe SW. Internal fixation for intraarticular distal radius fractures. Tech Hand Up Extrem Surg. 2002; 6:10-20.
37. Dodds SD, Cornelissen S, Jossan S, Wolfe SW. A biomechanical comparison of fragment-specific fixation and augmented external fixation for intra-articular distal radius fractures. J Hand Surg. 2002; 27:953-64.
38. Keller M, Steiger R. Open reduction and internal fixation of distal radius extension fractures in women over 60 years of age with the dorsal radius plate (pi-plate). Handchir Mikrochir Plast Chir. 2006; 38:82-9.
39. Jupiter JB, Ring D, Weitzel PP. Surgical treatment of redisplaced fractures of the distal radius in patients older than 60 years.J Hand Surg Am. 2002; 27:714-23.
40. Dumont C, Fuchs M, Folwaczny E, Heuermann C, Stürmer K. Results of palmar T-plate osteosynthesis in unstable fractures of the distal radius. Chirurg. 2003; 74:827-33.
41. Beharrie AW, Beredjiklian PK, Bozentka DJ. Functional outcomes after open reduction and internal fixation for treatment of displaced distal radius fractures in patients over 60 years of age. J Ortho Trauma. 2004; 18:680-6.