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Bridging External Fixation Augmented With Kirschner-Wire Fixation Versus Volar Locking Plate For Unstable Fractures Of The Distal Radius

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Abstract

Introduction: Distal radius fractures are much more prone to malunion than unstable extra-articular fractures. There is no clear consensus concerning what the proper treatment should be, and the best approach to use for displaced distal radius fractures remains challenging.

Aims and Objectives: In this prospective study, we aimed to compare the radiological, clinical, and functional results of a volar radius locking plate, and K-wire augmented bridging external fixator in the treatment of unstable distal radius fractures

Methods: From August 2019 to November 2021, 32 patients who had experienced unstable fractures of the distal radius were taken into this study in Govt. Hospital for Bone and Joint Surgery, assoc. hospital of Government Medical College, Srinagar. The patients were divided into two groups, one comprising of patients who were treated with internal fixation using the volar locking plate and the other group which had patients who were treated with external fixators augmented with K-wires. The primary outcome was a composite measure of the patient's quality of life using the MAYO score, DASH score, and assessment using the Green and O'Brien and the Gartland–Werley scoring system. The radiographic parameters included radial inclination, volar tilt, radial length, ulnar deviation, and articular step-off.

Results: A total of 32 patients were allocated randomly to two groups. The mean age for the external fixator group was 48.3 years and 41.5 years for the volar locking plate group. Grip power was significantly different between the two groups, but no significant differences were detected in the range of motion (p=0.007, p=0.295, respectively). The MAYO score was significantly higher in the open reduction and internal fixation (ORIF) group. The DASH score was not significantly different between the two groups (p=0.138). We observed that volar locking plates showed significantly better results than external fixation using the Green and O'Brien scoring and the Gartland–Werley scoring system. No difference between these two groups of patients was found in pain and activity. The ulnar deviation and articular step-off were significantly more improved in the volar locking plate group than the Ex Fix group, being 0.4 vs 1.3 mm (p = 0.002) and 0.4 vs 1.1mm (p = 0.006).

Conclusions: Volar locking plate fixation is a preferred surgical procedure to K-wire augmented bridging external fixator for the treatment of unstable distal radius fractures considering cost-effectiveness and earlier return to usual work due to better wrist mobility, correction of ulnar variance, and improved articular congruence with comparable overall functional outcomes and complication rate.

Keywords: Distal radius fracture, External fixator method, Internal fixation, Volar locking plate, Functional outcome

Introduction

Fracture of the distal radius is the most common type of fracture in the orthopedic emergency department, and more than 40% of them involve the articular surface [1]. A fracture of the distal radius that extends intra-articularly is completely unstable and is typically indicated for surgical treatment. Evidence has shown that a joint step of more than 2 mm can increase the risk of traumatic arthritis by more than fourfold [2, 3]; radial shortening caused increased pressure in the distal radioulnar joint [4], and dorsal angulation of 20° past the original position resulted in load transfer through the radioscaphoid and ulnocarpal joints [5, 6]. During the last 10 years, the volar locking plate (VLP) has gained the most popularity in the treatment of distal radius fractures due to its excellent biomechanical properties [7, 8]. In contrast, external fixation (EF) is not as widely used, but is preferred by a significant number of surgeons for its ease of application, improved reduction by ligamentotaxis, no need for a secondary procedure, and acceptable results. However, a higher rate of complications, including pin tract infection, loss of reduction, radial sensory nerve injury, and complex regional pain syndrome, should be feared [9–11]. Randomized controlled trials (RCTs) or cohort studies have demonstrated the advantages of VLP over EF for the treatment of distal radius fractures, especially in the early postoperative period [12–14]. Regarding the fracture of the distal radius that extends intra-articularly, the reported results have been different and even contradictory, whether treated with VLP or EF alone [3, 15, 16] or combined [5, 17]. However, to our knowledge, data directly comparing clinical or radiographic outcomes for the treatment of such fractures have been scarce [18, 19]. This study aimed to compare the EF and the VLP fixation for the treatment of unstable distal radius fractures, in terms of radiological outcomes, functional outcomes, and complications.

Materials and methods

This study was conducted between August 2019 to November 2021 in patients with distal radius fractures who visited Govt. Hospital for Bone and Joint Surgery, associated hospital of Government Medical College, Srinagar. This was a prospective study, approved by the ethics committee board of Government Medical College, Srinagar. Inclusion criteria were as follows: age of 18 years or older, a definite diagnosis of unstable distal radius fracture, fresh fracture, no prior surgery at the injured wrist, unilateral fracture, and no concomitant fracture at the injured limb. Exclusion criteria were old fractures, bilateral fractures of the distal radius, open fractures of the distal radius and associated head injuries and systematic skeletal diseases (e.g., hyperparathyroidism) or local disorder (e.g., tumors, Paget disease, or rheumatoid arthritis),

Surgical procedure:

For the External fixation group, all surgical procedures were performed by a single surgeon at a single institution using standard protocols under general or regional anesthesia. After the initial reduction maneuver, continuous mild traction was applied to maintain reduction and alignment. The general external fixation technique used two 2.5-mm Schanz pins in the second metacarpal and two 3.5-mm pins in the radius proximal to the fracture. The pins were connected and tightened with a solid connecting rod and connecting links. After applying the reduction frame, an inspection was performed in the C arm in the anteroposterior and lateral view (Fig. 2). Reduction was achieved in all cases by manual traction and a closed reduction method. Sterile betadine ligation was performed at the pin track site. In most cases, addition of two K-wires, generally one from the radial side and one from the ulnar side, were used for additional stability. Functional exercises of the shoulder, elbow, and finger joints were started in the early postoperative period (1–3 days) to prevent joint stiffness. At 6 weeks postoperatively, the K-wires and the external fixator was removed and wrist exercises were initiated. At 3 weeks, 6 weeks, and 3 months, a routine radiograph was taken to assess the state of the bone union.

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Figure 1 Pre-op AP and Lateral radiograph

Figure 2 Immediate Post-op AP and Lateral radiograph

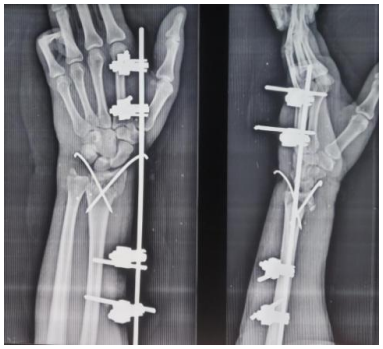

Figure 3 Clinical radiographs showing ROM and functional outcome at 1 year follow up

For the volar locking plate group, patients were operated under tourniquet in regional/general anesthesia in the supine position. A modified Henry approach was used to make a 08–10 cm longitudinal incision along the course of the flexor carpi radialis (FCR) muscle. The FCR tendon, flexor pollicis longus tendon, and radial nerve were retracted ulnarly, and the brachioradialis and radial blood vessels were retracted radially. The pronator quadrates muscle was then raised from the radial origin and retracted ulnarly to expose the fracture fragments. Each fragment was reduced and reconfirmed under fluoroscopic guidance. In the case of impacted

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fragments into the articular surface or metaphysis, a periosteal elevator is introduced to elevate the fragments. Temporary K-wire fixation was used to stabilize the reduced fragments. A 2.4 mm or 3.5 mm T-shaped locking plate and screws were placed with additional K-wires for auxiliary fixation if needed (Fig. 5). Postoperatively, immobilization was done for 2 weeks. Early motion of the finger, elbow, and shoulder was initiated on the first postoperative day. On the 14th day, the bandages and stitches were removed. On day 28, auxiliary K-wires were removed; active and passive rehabilitation of the wrist along with gradual strengthening was started.

Acceptable criteria for fracture reduction were:

1. Radial inclination >15^{o}.
2. Radial shortening of <5 mm compared to contralateral side.
3. Sagittal tilt between 15^{o} dorsal and 20^{o} volar tilt.
4. Intra-articular step-off of <2 mm.

Figure 4 Pre-op AP and Lateral radiograph showing intra-articular fracture of the distal end of radius

Figure 5 Immediate Post-op radiograph showing fixation by distal radius volar locking plate

Figure 6 Clinical radiographs showing ROM and functional outcome at 1 year follow up

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Follow-up and postoperative evaluation

The minimum follow-up period was 12 months. Objective functional outcomes were wrist range of motion and grip strength. A goniometer was used to measure flexion, extension, supination, and pronation. All these measurements were evaluated in comparison to the contralateral uninjured wrist, using a percentage indicator as an indicator. The patient-reported DASH scoring system [20], the Gartland-Werley scale [21], and the Green and O'Brien scoring system were used to indicate the overall functional outcome. The DASH questionnaire was used to assess patients' ability to perform daily activities with scores ranging from 0, representing no disability, to 100 points representing maximum disability (the higher the score, the more severe the disability). The Gartland-Werley scale is a validated medical scoring system that combines residual deformity, subjective findings, ROM, postoperative complications, and poor finger function. The scale ranges from 0 to 52 points, with a higher score indicating a worse outcome. Standard posteroanterior and lateral radiographs were used to measure volar inclination, radial inclination, radial length, ulnar deviation, and articular step. The Green and O'Brien scoring system was also used, and scores <65 were considered poor, and scores between 65 and 79, 80 and 89, and between 90 and 100 were considered fair, good, and excellent. At each visit (postoperative 2 weeks, 6 weeks, 3 months, 6 months, and 12 months), any potential complication was evaluated and documented, either from patient self-report or surgeon review, including infection, plate/screw loosening, neuropathy or nerve injury, tendon-related problems, loss of reposition, chronic regional pain syndrome, malunion, nonunion, refracture, and more.

Statistical analysis

All data were entered in SPSS 20.0 (IBM SPSS Inc. USA). The mean values of scores (age, surgical duration, volar tilt, radial inclination, radial length, ulnar deviation, and articular step-off) between the two techniques were compared by Student's t-test and scores at different intervals within the same group were compared by paired sample t-test.

Result

Thirty-Two unstable distal radius fractures were treated surgically from August 2019 to November 2021. The mechanism of injury was as follows: fall from a height (9), motor vehicle collision (8), sports-related injury (3), fall from a greater height (5), industrial machinery injury (2), and other (5). . Seventeen patients had right wrist involvement and 15 patients had left wrist involvement. Four (12.5%) patients had a concomitant ulnar styloid fracture. There were 12 men and 4 women in the VLP group and their average age was 41.5 years. There were 10 men and 6 women in the EF group with an average age of 48.3 years. There was no significant difference between the two groups with regard to age, gender, side of the injured wrist, hands, mechanism of injury, time to surgery, bone grafting, and length of follow-up ($p > 0.05$). A significantly longer operative time (75 min vs. 62 min, $p = 0.023$) was found in the VLP group compared to the EF group. All fractures achieved satisfactory reduction as seen on postoperative immediate radiographs. The mean follow-up was 15.2 months (range, 12 to 34 months). Results showed that VLP performed better in wrist flexion (68.5° vs 61.2°, $p < 0.002$), forearm pronation (71.9° vs 65.7°, $p = 0.026$) and supination (69.5° vs 62.4°, $p = 0.041$) EF. With respect to the other parameters (extension, ulnar deviation, and radial deviation), no significant difference ($p > 0.05$) was found (Table 4).

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Table 1. Mean and SD of age distribution in the external fixator and volar plate fixation groups, analyzed by t-test

Group	Minimum age (Year)	Maximum age (Year)	Mean (Year)	Standard deviation	P value
External fixator	27	49	48.3	4.2	0.193
Volar Plate	23	49	41.5	5.5	0.119
All patient	23	49	45	5.5	0.348

Table 2. Gender distribution in external fixator and volar plate fixation groups analyzed by Pearson Chi-Squared

Gender	Male		Female		All patients	
	n	%	n	%	n	%
External fixator group	10	62.5	6	37.5	16	100
Volar Plate fixation group	12	75	4	25	16	100
All patients	22	68.75	10	31.25	32	100
P value	p=0.123		p=0.345		p=0.022	

Table 2. Functional Results

	Group 1 (EF) (n=16)		**Group 2 (VLP) (n=16)**	**p-value***
	Mean (Standard deviation)		**Mean (Standard deviation)**	
Mayo score	73.97 (8.841)		76.55 (10.921)	0.117
Quick Dash score	5.41 (3.802)		4.94 (3.12)	0.548
Union time (week)	6.86 (0.849)		7.63 (1.297)	0.001
Gartland–Werley score (points)	3.7 (2.4)		2.5 (2.7)	0.086
Green and O'Brien	87.36 ± 11.62		81.55 ± 11.327	0.010

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score				
*Mann-Whitney U test, p<0.05. BEF: Bridging external fixator; VLP: Volar radial locking plate.				

Table 4. Comparison of wrist ROM and grip strength at the last visit

	External fixation		VLP fixation		
	Mean (sd)	% of the value on contralat. side	Mean (sd)	% of the value on contralat. side	
Flexion (deg)	61.2 (6.7)	89.6	68.5 (8.6)	95.6	< 0.001
Extension (deg)	60.2 (11.8)	92.7	61.1 (10.9)	93.7	0.657
Pronation (deg)	65.7 (8.6)	88.3	71.9 (9.7)	94.6	0.027
Supination (deg)	62.4 (9.9)	87.2	69.5 (10.5)	95.2	0.033
Radial deviation (deg)	19.4 (7.7)	90.4	19.7 (6.8)	91.3	0.798
Ulnar deviation (deg)	29.5 (4.6)	91.8	31.0 (5.7)	94.2	0.276
Grip strength (kg)	25.7 (6.2)	94.0	26.2 (7.4)	96.0	0.893
Volar tilt (degree)	12.35 (2.149)	90.1	12.52 (2.279)	93.2	0.594
Radial inclination (mm)	10.78 (3.039)	89.4	14.19 (2.959)	92.4	0.001
Radial length (mm)	7.85 (2.439)	91.4	10.50 (2.068)	94.3	0.001

Table 5. Comparison of Green and O'Brien score in two techniques at 6 months and 1-year follow-up

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	Volar plating	External fixator	*P* value	Volar plating	External fixator	*P* value
Pain	19.91 ± 4.6	21.22 ± 3.71	0.129	22.36 ± 2.86	21.33 ± 3.5	0.114
ROM	17.36 ± 6.2	19.67 ± 5.3	0.053	22.0 ± 4.77	19.89 ± 5.05	0.035
Grip strength	16.91 ± 5.3	16.78 ± 4.4	0.895	19.91 ± 5.4	16.89 ± 4.4	0.003
Activity	21.36 ± 4.4	22.67 ± 3.1	0.161	23.09 ± 2.6	23.44 ± 2.78	0.517
Final score	75.54 ± 17.7	80.33 ± 11.25	0.120	87.36 ± 11.62	81.55 ± 11.327	0.010

The mean grip strength of the operated wrist was 94% of that of the contralateral uninjured wrist in the VLP group, compared to 92% in the EF group (p = 0.893) (Table 4).

Regarding radiographic parameters, there is no significant difference in comparison of the volar slope, radial slope, or radial length (p > 0.05). The ulnar variance on the final radiographs in the VLP group was 0.6 ± 1.3 mm and in the EF group was 1.6 ± 1.8 mm, indicating a significant difference (p = 0.002). The radial-carpal articular distance in the VLP group was significantly smaller than in the EF group (0.5 ± 1.1 mm vs 1.2 ± 1.4 mm, p = 0.007) (Table 3). The VLP group showed better Gartland–Werley scores (2.5 ± 2.7 vs 3.7 ± 0.2.4) than the EF group, although the difference did not approach statistical significance (p = 0.086). Regarding the DASH, both groups showed similar superior performances, scoring 16 ± 12 in the EF group versus 12 ± 15 points in the VLP group (p = 0.162) (Table 3). In the EF group, 3 complications occurred indicating an incidence of 18.75% (3/16); pin infection was the most common complication, followed by complex regional pain syndrome . In the VLP group, there were 2 complications including 1 case of plate/screw problem (screw too long, or penetration) and 1 case of scar hypertrophy. The overall complication rate did not differ between the two groups (p = 0.587), although the difference appeared large (18.75% vs. 12.5%).

Discussion

Regarding unstable intra-articular fractures of the distal radius, various surgical procedures have been proposed, but none has shown superiority over the others [3, 19, 23–25]. The optimal treatment method of choice is still a controversial issue. In the study, we compared EF and VLP for the treatment of unstable distal radius fractures and demonstrated the superiority of VLP in preserving joint stability and joint congruence and improving joint mobility. However, at the final follow-up, total complications and functional scores based on the DASH or Gartland-Werley scale were not significantly different (p > 0.05). During the last decade, the use of VLP has gained the most popularity in the treatment of unstable fractures of the distal radius due to its advantages. The open method via the volar approach allowed good exposure of the fracture fragments for easy manipulation, which was more useful in the reduction of compressed or impacted fragments. The solid angle and locking screw/hole allowed small fragments to be secured and provided better support. In comparison, traction alone may not be effective in EF because ligamentotaxis primarily operates through the strong volar ligaments. This could be used to largely explain the difference in the final articular step (0.5 mm vs 1.2 mm) and ulnar variance (0.6 mm vs 1.6 mm) between the two methods. This result was consistent with previous reports where EF or VLP were applied to treat unstable distal radius fractures [26, 27]. In these studies, the researchers observed a difference of 0.8 mm (2.2 mm vs 1.4 mm, − 0.4 mm vs − 1.2 mm) in ulnar variance at the last visit (> 52 weeks). But in two other randomized trials, no difference was observed, neither for articular step-off nor for ulnar variance [18, 28]. We did not observe a significant difference in volar

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inclination value at the final follow-up, although VLP was superior to EF in correcting volar angulation and provided sufficient support with subchondral distal locking screws for a certain long time (eg, 12 months). In comparison, loss of volar angulation will continue even after removal of the external fixator, from 0.9° at immediate surgery to 4.2° at a 6-month follow-up [26]. Of note, the small sample size in both groups (16 each) should be of concern due to their lack of power to detect a true difference in volar inclination, likely leading to a type II statistical error. If an adequate sample size had been provided, the benefits of VLP in correcting and maintaining radiographic parameters would have been more statistically significant. Most previous studies have shown the advantages of VLP over EF in functional recovery in the early postoperative period (< 3 months) [19, 26]. But when it comes to medium-term results, there is controversy. In a retrospective cohort of 115 patients with C2/C3 type AO fractures, Richard et al. [10] demonstrated a better DASH score and a better pronation/supination arch in the VLP group at 12 months after surgery. Williksen et al. [26] performed an RCT study of 104 AO type C fractures and did not note a significant difference in DASH scores and other functional parameters between the two groups, but only better wrist supination (90° vs 76°) in the VLP group. In a study of 69 unstable distal radius fractures, wrist range and pronation were significantly better in the VLP group, while Gartland-Werley scores or patient-rated wrist evaluation (PRWE) were nonsignificantly different [19]. In this study, VLP showed significantly better performance in wrist flexion, pronation, and supination ($p < 0.05$). This may be attributed to the fact that VLP fixation allowed earlier mobilization of the wrist and maintained improved anatomical parameters until fracture union. Despite the advantages, VLP could not be used in some fracture types, for example, comminuted very distal fractures or osteoporotic fractures that do not allow screw insertion [27]. For such fractures, K-wire EF might be a better choice, which is more likely to yield successful results. Continuous external fixator distraction along with additional K-wires to secure comminuted fragments could provide more stability. In this study, more than 70% of EFs were supplemented with K-wires and indeed this showed excellent or good functional and radiographic results [24, 27].

Regarding complications, we found no significant difference in incidence, 18.75% in the EF group and 12.5% in the VLP group, both within the range of reported values [10, 18, 19, 26, 27]. Cao et al. [27] retrospectively reviewed 226 C3 distal radius fractures treated with an external fixator in elderly patients and reported rates of 18.6% (42/226) for overall complications, 10% for loss of reduction, 6.2% for joint stiffness, 2.2 % for traumatic arthritis and 0.5% for spinous tract infection. Richard et al. [10] reported a significantly higher overall complication rate in the EF group (52.5%, 31/59) than in the VLP group (25%, 14/56). In a meta-analysis of 9 RCTs, Esposito et al. [26] found a significantly higher incidence of overall complications or infection in EF versus VLP, but not significant for reoperation, osteoarthritis, malunion, nerve deficit, complex regional pain syndrome, painful retained hardware requiring removal, carpal tunnel syndrome, stiffness, tendon rupture, or tendonitis. It is often difficult to compare these different reported data due to differences in study design, patient characteristics, data collection, and follow-up periods. On the other hand, physician-reported and patient-reported complications differ, with the former emphasizing control-related complications, while the latter often takes symptoms as the main problem. McKay et al. [27] suggested that not all suboptimal outcomes should be considered complications unless they can be attributed to a specifically diagnosed complication.

Conclusion

In summary, VLP fixation demonstrated its superior performance in wrist mobility (wrist flexion, pronation, and supination), correction of ulnar deviation, and improvement of joint congruence. In terms of DASH, Gartland–Werley and Green and O'Brien scores, other radiographic or functional parameters, and complications, both fixation methods showed similar results. Future research with a better design and large sample size is needed to validate our results and explore potential contributors influencing adverse outcomes or complications.

References

1. Perey B, Grewal R, Wilmink M, Stothers K. A randomized prospective study on the treatment of intra-articular distal radius fractures: open reduction and internal fixation with dorsal plating versus mini open reduction, percutaneous

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fixation, and external fixation. *J Hand Surg [Am]* 2005;30:764-72.
2. Orbay J, Badia A, Khoury RK, Gonzalez E, Indriago I. Volar fixed-angle fixation of distal radius fractures: the DVR plate. *Tech Hand Up Extrem Surg* 2004;8:142-8.
3. Rozental TD, Blazar PE. Functional outcome and complications after volar plating for dorsally displaced, unstable fractures of the distal radius. *J Hand Surg [Am]* 2006;31:359- 65.
4. Varitimidis SE, Basdekis GK, Dailiana ZH, et al. Treatment of intra-articular fractures of the distal radius: fluoroscopic or arthroscopic reduction? *J Bone Joint Surg [Br]* 2008;90-B:778-85.
5. Wagner WF Jr, Tencer AF, Kiser P, Trumble TE. Effects on intra-articular distal radius depression on wrist joint contact characteristics. *J Hand Surg [Am]* 1996;21:554-60.
6. Trumble TE, Schmitt SR, Vedder NB. Factors affecting functional outcome of displaced intra-articular distal radius fractures. *J Hand Surg [Am]* 1994;19:325-40.
7. Forward DP, Davis TRC, Sithole JS. Do young patients with malunited fractures of the distal radius inevitably develop symptomatic post-traumatic arthritis? *J Bone Joint Surg [Br]* 2008;90-B:629-37.
8. Khanduja V, Ng L, Dannawi Z, Heras L. Complications and functional outcome following fixation of complex, intra-articular fractures of the distal radius with the AO Pi-Plate. *Acta Orthop Belg* 2005;71:672-7.
9. Al-Rashid M, Theivendran K, Craigen MAC. Delayed ruptures of the extensor tendon secondary to the use of volar locking compression plates for distal radial fractures. *J Bone Joint Surg [Br]* 2006;88-B:1610-12.
10. Arora R, Lutz M, Hennerbichler A, et al. Complications following internal fixation of unstable distal radius fracture with a palmar locking-plate. *J Orthop Trauma* 2007;21:316-22.
11. Ahlborg HG, Josefsson PO. Pin-tract complications in external fixation of fractures of the distal radius. *Acta Orthop Scand* 1999;70:116-18.
12. Botte MJ, Davis JL, Rose BA, et al. Complications of smooth pin fixation of fractures and dislocations in the hand and wrist. *Clin Orthop* 1992;276:194-201.
13. Glowacki KA, Weiss AP, Akelman E. Distal radius fractures: concepts and complications. *Orthopedics* 1996;19:601-8.
14. Paksima N, Panchal A, Posner MA, et al. A meta-analysis of the literature on distal radius fractures: a review of 615 articles. *Bull Hosp Jt Dis* 2004;62:40-6.
15. Kitaoka HB, Alexander IJ, Adelaar RS, et al. Clinical rating systems for the ankle hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 1994;15:349-53.
16. Orbay JL, Touhami A, Orbay C. Fixed angle fixation of distal radius fractures through a minimally invasive approach. *Tech Hand Up Extrem Surg* 2005;9:142-8.
17. Liporace FA, Gupta S, Jeong GS, et al. A biomechanical comparison of a dorsal 3.5-mm T-plate and a volar fixed-angle plate in a model of dorsally unstable distal radius fractures. *J Orthop Trauma* 2005;19:187-91.
18. Chung KC, Watt AJ, Kotsis SV, et al. Treatment of unstable distal radial fractures with the volar locking plating system. *J Bone Joint Surg [Am]* 2006;88-A:2687-94.
19. Margaliot Z, Haase SC, Kotsis SV, Kim HM, Chung KC. A meta-analysis of outcomes of external fixation versus plate osteosynthesis for unstable distal radius fractures. *J Hand Surg [Am]* 2005;30:1185-99.
20. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]: The Upper Extremity Collaborative Group (UECG). *Am J Ind Med* 1996;29:602-8.
21. No authors listed. Fracture and dislocation compendium: Orthopaedic Trauma Association Committee for coding and classification. *Orthopaedic Trauma* 1996;10(Suppl 1):1-155.
22. de Souza LJ, Gustilo RB, Meyer TJ. Results of operative treatment of displaced external rotation-abduction fractures of the ankle. *J Bone Joint Surg [Am]* 1985;67- A:1066-74.
23. Lafontaine M, Hardy D, Delince P. Stability assessment of distal radius fractures. *Injury* 1989;20:208-10.
24. Hoppenfield S, Deboer P. *Surgical exposures in orthopaedics: the anatomic approach*. Third ed. Philadelphia: Lippincott 2003:143-6.

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25. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. *J Bone Joint Surg [Am]* 1986;68-A:647-59.
26. Wakefield AE, McQueen MM. The role of physiotherapy and clinical predictors of outcome after fracture of the distal radius. *J Bone Joint Surg [Br]* 2000;82-B:972-6.
27. Handoll HH, Madhok R. Surgical interventions for treating distal radial fractures in adults. *Cochrane Database Syst Rev* 2003;4:CD003209.

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