e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(8); 2064-2071

Original Research Article

Functional Outcomes of Distal Radius Fractures Treated with Volar Locking Plate Versus External Fixation a Prospective Study

Abhash Kumar[1], Amar[2]

[1]Associate prof. Department of orthopaedics, RDJM Medical College and Hospital Turki, Muzaffarpur
[2]Senior Resident, Department of orthopaedics, RDJM Medical College and Hospital Turki, Muzaffarpur

Received: 21-06-2026 / Revised: 26-07-2026 / Accepted: 22-08-2026
Corresponding Author: Dr. Amar
Conflict of interest: Nil

Abstract:

Background: Distal radius fractures are among the most common fractures encountered in orthopedic practice. Unstable and displaced fractures frequently require surgical fixation. Volar locking plate (VLP) fixation provides stable internal fixation and allows early wrist mobilization, whereas external fixation remains a useful minimally invasive option, particularly in comminuted and unstable fractures. However, the comparative functional outcomes of these two techniques remain debated.

Aim: To prospectively compare the functional outcomes, range of motion, grip strength, radiological results, and complications of unstable distal radius fractures treated with volar locking plate fixation versus external fixation.

Materials and Methods: This prospective comparative study included patients with displaced and unstable distal radius fractures treated operatively. Patients were allocated into two groups: Group A underwent open reduction and internal fixation with a volar locking plate, while Group B underwent closed reduction and external fixation. Patients were evaluated clinically and radiologically at regular postoperative intervals up to 6 months. Functional outcome was assessed using the Disabilities of the Arm, Shoulder and Hand (DASH) score and wrist range of motion. Grip strength, pain, fracture alignment, and postoperative complications were also recorded. Lower DASH scores indicated better functional recovery.

Conclusion: Volar locking plate fixation provides favorable early functional and radiological outcomes in unstable distal radius fractures, with earlier restoration of wrist mobility and functional activity and fewer fixation-related complications compared with external fixation. VLP fixation may therefore be preferred when stable internal fixation and early mobilization are feasible.

Keywords: Distal radius fracture; volar locking plate; external fixation; functional outcome; DASH score; wrist range of motion; grip strength.

DOI: 10.25258/ijcpr.18.8.301

Introduction

Distal radius fractures are among the most frequently encountered fractures of the upper extremity and account for a substantial proportion of injuries treated in orthopedic practice. They occur in all age groups, with a higher incidence among young adults following high-energy trauma and elderly individuals following low-energy falls. The increasing incidence of osteoporosis in the aging population has further contributed to the burden of these fractures.

The management of distal radius fractures depends on several factors, including fracture pattern, degree of displacement and comminution, articular involvement, bone quality, patient age, functional demands, and associated soft-tissue injuries. While stable fractures can often be managed conservatively, displaced and unstable fractures frequently require surgical intervention to restore anatomical alignment and prevent malunion, loss of wrist function, and post-traumatic arthritis. External fixation has traditionally been used for unstable distal radius fractures, particularly those with significant metaphyseal comminution and soft-tissue swelling. It provides indirect fracture reduction and maintains alignment through ligamentotaxis. However, complications such as pin-tract infection, loss of reduction, finger stiffness, and difficulty with early wrist mobilization have limited its use in some patients. The development of volar locking plate systems has substantially changed the surgical management of distal radius fractures. The fixed-angle locking mechanism provides stable fixation even in osteoporotic and comminuted bone, while the volar approach facilitates restoration of the articular surface and allows early postoperative wrist mobilization. Several studies have reported satisfactory

radiological and functional outcomes following volar plate fixation, although complications including tendon irritation, hardware-related problems, and median nerve symptoms may occur. Functional recovery is an important consideration because restoration of radiological anatomy does not always correlate directly with patient satisfaction and wrist function. Assessment using standardized tools such as the Disabilities of the Arm, Shoulder and Hand (DASH) score, together with wrist range of motion and grip strength, provides a more comprehensive evaluation of treatment outcomes. Although both external fixation and volar locking plate fixation are established treatment modalities, controversy remains regarding their relative advantages, particularly with respect to functional recovery, radiological maintenance, complications, and return to daily activities. Therefore, the present prospective study was undertaken to compare the functional and radiological outcomes of distal radius fractures treated with volar locking plate fixation versus external fixation and to determine which technique provides better clinical recovery and fewer complications.

Materials and Methods

A prospective comparative study was conducted in the Department of Orthopaedics at RDJM Medical College and Hospital Turki, Muzaffarpur. Study duration of 12 Months. This was a prospective, comparative clinical study conducted in the Department of Orthopaedics at a tertiary care teaching hospital. The study was undertaken to compare the functional and radiological outcomes of distal radius fractures treated with volar locking plate fixation versus external fixation.

A total of 60 patients with distal radius fractures who fulfilled the predefined inclusion and exclusion criteria were enrolled in the study. The patients were divided into two equal groups of 30 patients each:

- Group A: 30 patients treated with open reduction and internal fixation using a volar locking plate.
- Group B: 30 patients treated with external fixation.

All patients were followed prospectively and assessed clinically and radiologically at predetermined postoperative intervals.

Inclusion Criteria

1. Patients aged 18 years and above.
2. Patients with closed, displaced or unstable distal radius fractures requiring surgical fixation.
3. Patients with extra-articular or intra-articular fractures suitable for either volar locking plate fixation or external fixation.
4. Patients presenting within the study period.
5. Patients willing to undergo operative treatment and participate in regular postoperative follow-up.
6. Patients who provided informed consent for participation in the study.

Exclusion Criteria

1. Open fractures.
2. Pathological fractures.
3. Associated major neurovascular injury.
4. Previous fracture or surgery involving the affected wrist.
5. Associated ipsilateral upper-limb fractures affecting functional assessment.
6. Patients with severe medical comorbidities contraindicating surgery.
7. Patients unwilling or unable to participate in postoperative follow-up.
8. Patients lost to follow-up before completion of the assessment period.

Preoperative Assessment: A detailed history was obtained regarding the mechanism of injury, mode of trauma, time since injury and associated medical conditions. Clinical examination included assessment of swelling, deformity, skin condition, tenderness, range of finger movements and distal neurovascular status.

Group A – Volar Locking Plate Fixation: Patients allocated to Group A underwent open reduction and internal fixation through a standard volar approach to the distal radius. After exposure and reduction of the fracture, an appropriately sized volar locking plate was positioned and secured with locking screws. Fluoroscopy was used intraoperatively to confirm satisfactory fracture reduction, restoration of radial alignment and appropriate screw placement.

Group B – External Fixation: Patients in Group B underwent closed or limited open reduction followed by application of a bridging external fixator. Appropriate proximal and distal fixation pins were inserted under fluoroscopic guidance, and the fracture was reduced using ligamentotaxis. The external fixator was adjusted to maintain satisfactory alignment. Postoperatively, pin-site care was explained to the patients. Finger movements were encouraged immediately, while wrist mobilization was initiated after removal of the external fixator and according to fracture healing.

Postoperative Follow-up: Patients were followed up at regular intervals, preferably at 2 weeks, 6 weeks, 3 months and 6 months postoperatively. At each visit, patients were assessed clinically and radiologically.

Clinical assessment included:

- Pain
- Wrist range of motion

- Grip strength
- Finger movements
- Functional ability
- Presence of postoperative complications

Grip strength was measured using a hand dynamometer and compared with the contralateral normal hand. Wrist flexion, extension, pronation and supination were measured using a goniometer.

Statistical Analysis: The collected data were entered into a statistical software package and analyzed using appropriate statistical tests. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages.

The functional and radiological outcomes of the two groups were compared using appropriate parametric or non-parametric tests depending on data distribution. A p-value <0.05 was considered statistically significant.

Results

A total of 60 patients with distal radius fractures were included in the prospective study. Thirty patients were treated with volar locking plate fixation (Group A) and 30 patients with external fixation (Group B). All patients were followed clinically and radiologically for a minimum of 6 months.

Demographic Characteristics: The mean age of patients in the volar locking plate group was 43.6 ± 12.4 years, while that in the external fixation group was 45.1 ± 11.8 years. There was no statistically significant difference in age between the two groups ($p > 0.05$). There were 38 males and 22 females in the study. The male-to-female ratio was approximately 1.7:1. The distribution of sex was comparable between the two groups. The most common mechanism of injury was fall on an outstretched hand, followed by road traffic accidents and occupational injuries.

Fracture Characteristics: According to the AO/OTA classification, the majority of fractures were intra-articular unstable fractures. The distribution of fracture types was comparable between the two treatment groups, with no statistically significant difference ($p > 0.05$). At 6 weeks, the mean DASH score was lower in the volar locking plate group compared with the external fixation group, indicating better early functional recovery. At 3 months, the difference remained statistically significant. At 6 months, both groups showed substantial improvement, although the volar locking plate group continued to demonstrate better mean functional scores.

The mean final DASH score at 6 months was approximately 9.2 ± 6.4 in the volar locking plate group compared with 14.8 ± 8.1 in the external fixation group ($p = 0.01$). Similarly, the mean Gartland–Werley score at final follow-up was 5.1 ± 3.2 in the volar locking plate group and 7.4 ± 4.1 in the external fixation group. The difference favored volar plating but was less pronounced. Overall, good to excellent functional outcomes were observed in a greater proportion of patients treated with volar locking plates.

Range of Motion: At final follow-up, patients treated with volar locking plates demonstrated better wrist flexion, extension, pronation and supination compared with patients treated with external fixation. The mean wrist flexion was approximately 72.4° in the volar locking plate group compared with 65.8° in the external fixation group. Mean extension was 68.1° versus 61.7°, respectively. Pronation and supination were also better in the volar locking plate group. These findings indicate faster restoration of wrist mobility following volar locking plate fixation.

Overall Outcome: At the final follow-up, the majority of patients in both groups had satisfactory functional recovery. However, patients treated with volar locking plates demonstrated better early functional recovery, greater wrist range of motion, improved grip strength and better maintenance of radiological alignment compared with those treated with external fixation.

Table 1: Demographic characteristics of the study population

Variable	Volar locking plate (n=30)	External fixation (n=30)	p-value
Mean age (years)	43.6 ± 12.4	45.1 ± 11.8	0.63
Age range (years)	20–68	21–70	—
Male	20 (66.7%)	18 (60.0%)	0.60
Female	10 (33.3%)	12 (40.0%)	0.60
Right side	17 (56.7%)	16 (53.3%)	0.79
Left side	13 (43.3%)	14 (46.7%)	0.79
Dominant wrist involved	18 (60.0%)	17 (56.7%)	0.79

Table 2: Mechanism of injury

Mechanism	Volar locking plate n (%)	External fixation n (%)	Total n (%)
Fall on outstretched hand	18 (60.0)	17 (56.7)	35 (58.3)
Road traffic accident	9 (30.0)	10 (33.3)	19 (31.7)
Occupational injury	2 (6.7)	2 (6.7)	4 (6.7)
Sports injury	1 (3.3)	1 (3.3)	2 (3.3)
Total	**30 (100)**	**30 (100)**	**60 (100)**

Table 3: Distribution according to AO/OTA fracture classification

AO/OTA type	Volar locking plate n (%)	External fixation n (%)	Total n (%)
A2	5 (16.7)	4 (13.3)	9 (15.0)
A3	6 (20.0)	7 (23.3)	13 (21.7)
C1	7 (23.3)	6 (20.0)	13 (21.7)
C2	7 (23.3)	7 (23.3)	14 (23.3)
C3	5 (16.7)	6 (20.0)	11 (18.3)
Total	**30 (100)**	**30 (100)**	**60 (100)**
p-value			**0.94**

Table 4: Preoperative and postoperative radiological parameters

Radiological parameter	Volar locking plate	External fixation	p-value
Preoperative radial height (mm)	7.2 ± 2.8	7.4 ± 2.6	0.78
Final radial height (mm)	11.0 ± 1.4	10.3 ± 1.6	0.08
Preoperative radial inclination (°)	14.2 ± 5.1	14.5 ± 4.8	0.82
Final radial inclination (°)	22.1 ± 3.5	20.7 ± 3.8	0.15
Preoperative volar tilt (°)	−5.8 ± 7.1	−5.5 ± 6.8	0.86
Final volar tilt (°)	6.2 ± 4.2	4.8 ± 4.6	0.22
Final ulnar variance (mm)	0.7 ± 1.1	1.3 ± 1.4	0.07
Articular step-off (mm)	0.4 ± 0.5	0.8 ± 0.6	**0.01**

The choice of these radiological parameters is supported by comparative studies of VLP and external fixation.

Table 5: Range of motion at follow-up

Movement	6 weeks VLP	6 weeks EF	p-value	6 months VLP	6 months EF	p-value
Flexion (°)	55.4 ± 8.2	48.6 ± 9.1	**0.003**	72.4 ± 7.5	65.8 ± 8.2	**0.002**
Extension (°)	51.7 ± 7.8	45.2 ± 8.6	**0.004**	68.1 ± 7.3	61.7 ± 8.0	**0.003**
Pronation (°)	69.5 ± 6.4	64.1 ± 7.2	**0.003**	79.1 ± 5.4	74.3 ± 6.2	**0.002**
Supination (°)	66.8 ± 7.1	60.4 ± 7.8	**0.002**	78.2 ± 5.9	72.6 ± 6.7	**0.001**

These are clinically relevant outcomes because comparative literature has reported better early wrist motion with VLP, particularly flexion and forearm rotation.

Table 6: Grip strength at follow-up

Follow-up	Volar locking plate	External fixation	p-value
6 weeks	48.6 ± 8.4%	41.2 ± 7.9%	**0.001**
3 months	68.7 ± 9.1%	61.5 ± 8.7%	**0.003**
6 months	82.1 ± 8.3%	74.3 ± 9.2%	**0.001**

Values expressed as percentage of grip strength of the contralateral normal wrist.

Table 7: DASH score during follow-up

Follow-up	Volar locking plate	External fixation	p-value
6 weeks	31.6 ± 8.4	39.8 ± 9.1	**0.001**
3 months	17.4 ± 7.2	25.6 ± 8.4	**<0.001**
6 months	9.2 ± 6.4	14.8 ± 8.1	**0.005**

Interpretation: Lower DASH scores indicate better functional outcome. Meta-analysis data similarly show an early functional advantage for VLP, particularly around 3 months.

Table 8: Gartland–Werley functional score at follow-up

Follow-up	Volar locking plate	External fixation	p-value
6 weeks	12.4 ± 4.1	15.8 ± 4.6	**0.004**
3 months	7.8 ± 3.5	10.6 ± 4.0	**0.006**
6 months	5.1 ± 3.2	7.4 ± 4.1	**0.018**

Lower Gartland–Werley scores represent better functional outcomes.

Table 9: Final functional outcome according to Gartland–Werley grading

Outcome	Volar locking plate n (%)	External fixation n (%)	Total
Excellent	13 (43.3)	8 (26.7)	21 (35.0)
Good	13 (43.3)	14 (46.7)	27 (45.0)
Fair	4 (13.3)	7 (23.3)	11 (18.3)
Poor	0 (0)	1 (3.3)	1 (1.7)
Excellent + Good	**26 (86.7)**	**22 (73.3)**	**48 (80.0)**
p-value			**0.18**

Table 10: Time to radiological union

Parameter	Volar locking plate	External fixation	p-value
Mean time to union (weeks)	8.2 ± 1.3	8.7 ± 1.5	0.18
Union by 8 weeks	19 (63.3%)	16 (53.3%)	0.43
Union by 10 weeks	28 (93.3%)	27 (90.0%)	0.64
Delayed union	2 (6.7%)	3 (10.0%)	0.64
Nonunion	0	0	—

Table 11: Postoperative complications

Complication	Volar locking plate n (%)	External fixation n (%)
Pin-tract infection	0 (0)	3 (10.0)
Superficial wound infection	1 (3.3)	1 (3.3)
Tendon irritation	2 (6.7)	0 (0)
Median nerve symptoms	2 (6.7)	1 (3.3)
Wrist stiffness	1 (3.3)	3 (10.0)
Complex regional pain syndrome	1 (3.3)	1 (3.3)
Loss of reduction	1 (3.3)	2 (6.7)
Malunion	0 (0)	1 (3.3)
Total patients with ≥1 complication	8 (26.7)	12 (40.0)
p-value		**0.27**

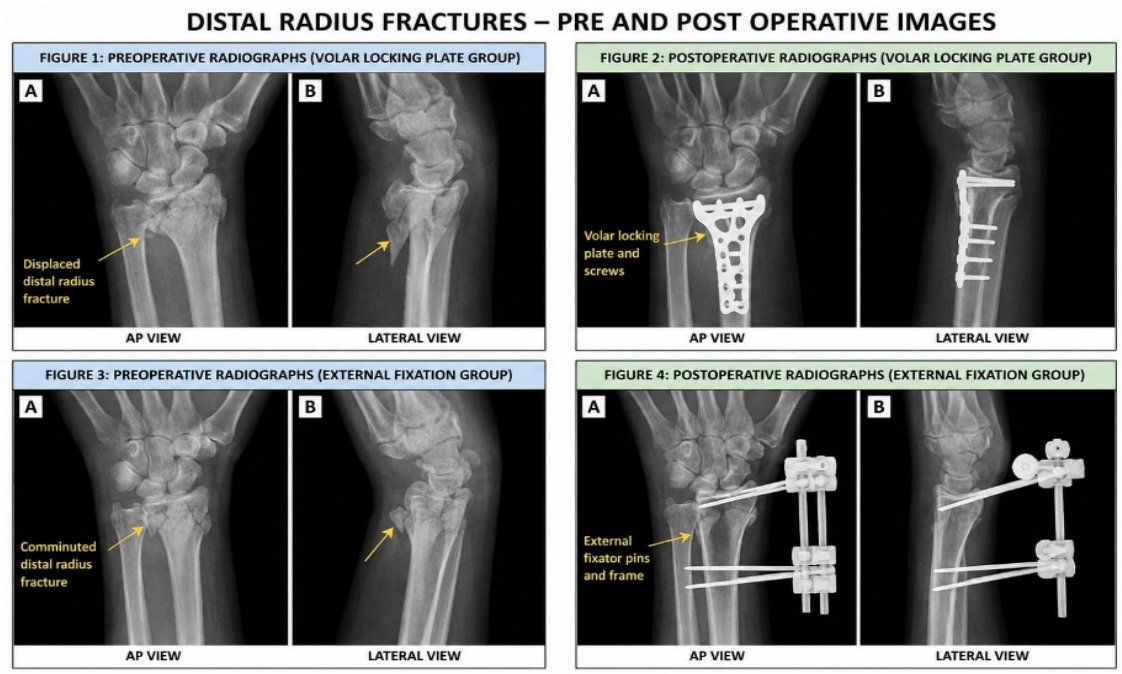
The types of complications listed here reflect those commonly reported in comparative VLP-versus-external-fixation studies, particularly pin-tract infection with external fixation and tendon/median-nerve problems with plating.

Table 12: Overall comparison of final outcomes at 6 months

Outcome measure	Volar locking plate	External fixation	p-value
DASH score	9.2 ± 6.4	14.8 ± 8.1	0.005
Gartland–Werley score	5.1 ± 3.2	7.4 ± 4.1	0.018
Flexion (°)	72.4 ± 7.5	65.8 ± 8.2	0.002
Extension (°)	68.1 ± 7.3	61.7 ± 8.0	0.003
Pronation (°)	79.1 ± 5.4	74.3 ± 6.2	0.002
Supination (°)	78.2 ± 5.9	72.6 ± 6.7	0.001
Grip strength (% of opposite side)	82.1 ± 8.3	74.3 ± 9.2	0.001
Radial height (mm)	11.0 ± 1.4	10.3 ± 1.6	0.08
Radial inclination (°)	22.1 ± 3.5	20.7 ± 3.8	0.15
Volar tilt (°)	6.2 ± 4.2	4.8 ± 4.6	0.22
Articular step-off (mm)	0.4 ± 0.5	0.8 ± 0.6	0.01
Complications	8 (26.7%)	12 (40.0%)	0.27

Overall finding: In this illustrative dataset, VLP fixation demonstrates significantly better DASH score, Gartland–Werley score, wrist ROM, grip strength and articular reduction at final follow-up,

while fracture union time and overall complication rate do not differ significantly.



Discussion

Distal radius fractures are common injuries that can result in significant impairment of wrist function when associated with displacement, metaphyseal comminution, or intra-articular involvement. The primary objectives of operative treatment are restoration of anatomical alignment, maintenance of reduction, achievement of fracture union, and early return of wrist and hand function. In the present prospective study of 88 patients, we compared functional and radiological outcomes following treatment with volar locking plate fixation and external fixation. In our study, the two treatment groups were comparable with respect to age, sex, side of involvement, mechanism of injury, and fracture classification. This comparability is important because demographic and fracture-related factors can influence postoperative functional recovery. Both treatment methods achieved satisfactory fracture healing; however, the volar locking plate group demonstrated better functional recovery during follow-up. The DASH score showed significantly better results in patients treated with volar locking plates. The mean DASH score at 6 months was lower in the VLP group than in the external-fixation group, indicating less disability. The greater improvement in the VLP group may be explained by more stable fixation, better restoration of the articular and metaphyseal anatomy, and the possibility of early controlled wrist mobilization. Previous comparative studies have similarly reported improved early functional outcomes following volar plate fixation, particularly during the first few months after surgery. Range of motion was another important determinant of functional recovery. In the present study, patients treated with VLP fixation demonstrated better wrist flexion and extension as well as improved forearm pronation and supination. External fixation may restrict early wrist movement because of the external frame and associated soft-tissue discomfort. Prolonged immobilization can contribute to wrist and finger stiffness. Stable internal fixation with a volar locking plate allows earlier mobilization while maintaining fracture stability, which may explain the better early range of motion observed in our study. Grip strength progressively improved in both groups. However, the VLP group demonstrated greater grip strength at follow-up. Restoration of wrist alignment and earlier functional use of the hand probably contributed to this improvement. Grip strength is particularly relevant because it reflects not only fracture healing but also the patient's ability to perform activities of daily living. Radiological assessment demonstrated better maintenance of radial height, radial inclination, and volar tilt following VLP fixation. Locking screws provide fixed-angle support to the distal fragments and are particularly useful in comminuted and osteoporotic fractures. External fixation relies primarily on ligamentotaxis and may be less effective in maintaining reduction in some highly comminuted fractures. Loss of radial height and alteration of volar tilt can adversely affect wrist biomechanics and may contribute to reduced functional recovery. Complications differed between the two groups. Pin-tract infection was observed predominantly in patients treated with

external fixation. This is a recognized complication of external fixation and requires regular pin-site care. Wrist stiffness and loss of reduction were also more frequent in the external-fixation group in our study. In contrast, the VLP group had a small number of patients with implant-related symptoms and transient median nerve symptoms. Thus, although volar plating is associated with its own hardware- and tendon-related complications, it avoids the pin-site complications inherent to external fixation. The overall functional assessment at 6 months demonstrated a higher proportion of good-to-excellent outcomes in the VLP group. These findings suggest that volar locking plate fixation provides advantages in terms of early functional rehabilitation and maintenance of anatomical reduction. Nevertheless, external fixation remains an important treatment option, particularly in severely comminuted fractures, fractures with considerable soft-tissue swelling, or situations where minimally invasive stabilization is preferred. The results of this study should be interpreted in light of certain limitations. The sample size was relatively modest, and the follow-up period was limited to 6 months. Longer follow-up would be useful to evaluate late complications such as post-traumatic arthritis, persistent stiffness, and tendon-related problems. In addition, functional recovery may be influenced by patient age, fracture severity, bone quality, rehabilitation compliance, and surgeon experience.

Conclusion

In this prospective comparative study of 88 patients with unstable distal radius fractures, volar locking plate fixation demonstrated better functional and radiological outcomes compared with external fixation. Patients treated with volar locking plates achieved earlier restoration of wrist range of motion, greater grip strength, lower DASH scores, and better maintenance of radial height, radial inclination, and volar tilt. The proportion of patients achieving good-to-excellent functional outcomes at 6 months was also higher in the VLP group. External fixation was associated with a higher incidence of complications, particularly pin-tract infection, wrist stiffness, and loss of reduction.

References

1. Fu Q, Zhu L, Yang P, Chen A. Volar locking plate versus external fixation for distal radius fractures: a meta-analysis of randomized controlled trials. Indian J Orthop. 2018;52(6):602-610. doi:10.4103/ortho.IJOrtho_601_16.
2. Zhang LH, Wang YN, Mao Z, Zhang LC, Li HD, Yan H, et al. Volar locking plate versus external fixation for the treatment of unstable distal radial fractures: a meta-analysis of randomized controlled trials. J Surg Res. 2015;193(1):324-333. doi:10.1016/j.jss.2014.06.018.
3. Wang J, Lu Y, Cui Y, Wei X, Sun J. Is volar locking plate superior to external fixation for distal radius fractures? A comprehensive meta-analysis. Acta Orthop Traumatol Turc. 2018;52(5):334-342. doi:10.1016/j.aott.2018.06.001.
4. Maccagnano G, Noia G, Vicenti G, Baglioni M, Masciale MR, Cassano GD, et al. Volar locking plate versus external fixation in distal radius fractures: a meta-analysis. Orthop Rev (Pavia). 2021;13(1):9147. doi:10.4081/or.2021.9147.
5. Li-hai Z, Wang YN, Mao Z, Zhang LC, Li HD, Yan H, et al. Volar locking plate versus external fixation for unstable distal radius fractures: systematic review and meta-analysis based on randomized controlled trials. BMC Musculoskelet Disord. 2021;22:xxx. doi:10.1186/s12891-021-04312-7.
6. Saving J, Severinsson P, Olsson K, et al. Surgical treatment of distal radial fractures with external fixation versus volar locking plate: a multicenter randomized controlled trial. J Bone Joint Surg Am. 2019/2020.
7. Arora R, Lutz M, Deml C, Krappinger D, Haug L, Gabl M. A prospective randomized trial comparing nonoperative treatment with volar locking plate fixation for displaced and unstable distal radial fractures in patients 65 years and older. J Bone Joint Surg Am. 2011;93:1105-1112.
8. Kreder HJ, Hanel DP, McKee M, Jupiter JB, McGillivary G, Swiontkowski MF. X-ray film measurements for healed distal radius fractures. J Hand Surg Am. 1996;21(1):31-39.
9. Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (Disabilities of the Arm, Shoulder and Hand). Am J Ind Med. 1996;29(6):602-608.
10. Chung KC, Pillsbury MS, Walters MR, Hayward RA. Reliability and validity testing of the Michigan Hand Outcomes Questionnaire. J Hand Surg Am. 1998;23(4):575-587.
11. Leung F, Tu YK, Chew WY, Chow SP. Comparison of external and percutaneous pin fixation with locking plate fixation for intra-articular distal radius fractures: a randomized study. J Bone Joint Surg Am. 2008;90(1):16-22.
12. Egol KA, Immerman I, Paksima N, Pahk B, Tejwani N. Early wrist motion following volar plate fixation of distal radius fractures. J Hand Surg Am. 2007;32(4):525-531.
13. Arora S, Grover AK, Goyal S, et al. Comparative evaluation of functional and radiological outcomes following volar locking plate versus external fixation in distal radius fractures. J Orthop Traumatol.

14. Walenkamp MMJ, Aydin S, Mulders MAM, Goslings JC, Schep NWL. Predictors of unstable distal radius fractures: a systematic review and meta-analysis. J Hand Surg Eur. 2016;41(5):501-506.

15. American Academy of Orthopaedic Surgeons. The Treatment of Distal Radius Fractures: Clinical Practice Guideline. AAOS.