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RESEARCH ARTICLE

Minimally Invasive Kirschner Wiring Versus Volar Plate Fixation for Extra-Articular Distal Radius Fractures: Does Less Invasive Surgery Deliver Equal Outcomes?

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ABSTRACT

Objective: Extra-articular distal radius fractures are common injuries for which percutaneous kirschner wire fixation (PKW) and volar locking plate (VLP) fixation remain widely used surgical approaches. Despite their frequent application, the comparative effectiveness of these techniques—particularly regarding early postoperative recovery and long-term functional outcomes—continues to be debated. This study aimed to compare the clinical, functional, and radiological results of PKW versus VLP in adult patients with extra-articular distal radius fractures.

Materials and Methods: This retrospective cohort study included adult patients treated surgically for extra-articular distal radius fractures (AO/OTA 2R3A2–2R3A3) between 2017 and 2024. Patients were assigned to PKW or VLP based on the surgical approach. Demographic characteristics, postoperative pain, functional outcomes (DASH, PRWE), and radiographic parameters were evaluated. Postoperative measures were analyzed. Statistical significance was set at $p<0.05$.

Results: Sixty-two patients met the inclusion criteria (PKW: n=24; VLP: n=38). Early postoperative pain was significantly lower in the PKW group on day 1 ($p<0.001$), and hospital stay was shorter compared with VLP ($p<0.001$). By 6 weeks and at final follow-up, VAS scores were comparable. DASH and PRWE scores showed no significant differences between the techniques. Radiographic restoration of alignment was similar between groups, and complication rates were low in both cohorts.

Conclusion: PKW and VLP provide equivalent long-term functional and radiological outcomes in extra-articular distal radius fractures. PKW offers distinct advantages in early recovery, including reduced postoperative pain and shorter hospitalization, supporting its use as a minimally invasive and effective alternative in appropriately selected patients.

Keywords: Distal radius fracture, functional outcomes, kirschner wire fixation, volar locking plate

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INTRODUCTION

Distal radius fractures are among the most common fractures encountered in adult trauma, and a substantial proportion of these injuries present with extra-articular patterns, making them a frequent reason for emergency department admissions.[1–4] High-energy trauma typically results in comminuted and intra-articular fractures, whereas low- to moderate-energy mechanisms more often lead to simpler extra-articular fractures. While open reduction and internal fixation are commonly preferred for comminuted intra-articular fractures, conservative management remains the mainstay of treatment for extra-articular injuries.[5,6]

Both conservative and surgical approaches may be employed in the management of distal radius fractures. Throughout

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the treatment course, multiple decision points arise for both the patient and the clinician. Each therapeutic option and overall management strategy carries its own risk–benefit profile, making careful evaluation of the available evidence essential for shared decision-making. Current guidelines aim to support clinical judgment by helping surgeons select the most appropriate treatment modality that offers the highest expected benefit.[7]

It is well established that functional recovery is closely linked to the proper restoration of skeletal anatomy. Accordingly, the chosen treatment for distal radius fractures should maintain the fracture fragments in anatomic alignment until union, prevent loss of reduction, and enable early and effective functional rehabilitation. The primary goals of distal radius fracture management are to achieve a painless wrist with a congruent joint surface, ensure anatomical reduction of the fracture, and facilitate timely and optimal restoration of function.[8] In extra-articular, non-comminuted, and stable fracture patterns, closed reduction and cast immobilization are typically the preferred initial approach; however, if acceptable alignment cannot be achieved or maintained with casting, surgical intervention should be considered.[5,6]

Among the commonly used operative techniques, the relative advantages of closed reduction followed by percutaneous Kirschner wire fixation (PKW) and open reduction with volar locking plate (VLP) fixation remain a matter of ongoing debate.[5] This study aims to provide evidence-based insights for indication-driven decision-making by comparing the clinical and functional outcomes, as well as the complication profiles, of "Closed Reduction + K-wire fixation" versus "Open Reduction + Plate-screw fixation" approaches in extra-articular distal radius fractures.

MATERIALS and METHODS

This study is a retrospective cohort analysis including adult patients who underwent surgical treatment for extra-articular distal radius fractures (AO/OTA 2R3A2–2R3A3) in our Department of Orthopaedics and Traumatology between 2017 and 2024. The majority of fractures demonstrated simple extra-articular morphology consistent with AO/OTA A2 patterns; however, in some patients, the presence of small metaphyseal fragments resulted in borderline fracture characteristics between A2 and A3. As a clear distinction between A2 and A3 could not be reliably established in all such cases, both categories were considered together to accurately reflect fracture morphology and avoid misclassification. Ethical approval was obtained from our institutional review board, and informed consent was secured from all patients prior to inclusion.

Data were obtained from hospital medical records. In cases with incomplete documentation or when additional clarification was required, missing information was supplemented during routine outpatient follow-up visits or through structured telephone interviews. Only patients with complete medical records who met the predefined inclusion criteria were enrolled in the study. Demographic variables collected included age and sex.

Inclusion criteria were as follows: adults aged 18–65 years, unilateral fractures, and surgical treatment performed within two weeks after low-energy trauma. Exclusion criteria included open fractures; fractures with intra-articular extension (AO/OTA 2R3B–2R3C); polytrauma; additional fractures of the ipsilateral or contralateral upper extremity related to the same injury; pathological fractures; metabolic or systemic disorders known to impair healing (e.g., diabetes mellitus, chronic renal disease, long-term corticosteroid use); the presence of neurovascular compromise; soft-tissue infection at the surgical site; prior surgery on the same wrist; failure to attend follow-up; insufficient, unverifiable, or incomplete medical records; and a follow-up duration shorter than 12 months.

Patients were categorized into two groups: Group 1 consisted of those treated with closed reduction followed by percutaneous Kirschner wire fixation (PKW), and Group 2 included patients who underwent open reduction with volar locking plate (VLP) fixation. The choice of surgical method was determined by intraoperative and preoperative clinical assessment, taking into account soft-tissue condition, patient-related factors, and surgeon preference.

Surgical Techniques

PKW technique: Closed reduction of the fracture was performed under fluoroscopic guidance, followed by percutaneous fixation with Kirschner wires inserted through the radial styloid and dorsoulnar aspects of the distal radius (Fig. 1). The wires were bent and left outside the skin. Pin sites were dressed regularly, and all wires were removed at the 5-week follow-up.

VLP technique: A standard volar approach using the modified Henry incision was employed, entering between the flexor carpi radialis tendon and the radial artery. After exposing the distal radius and the fracture site, open reduction was achieved, and fixation was performed with a volar locking

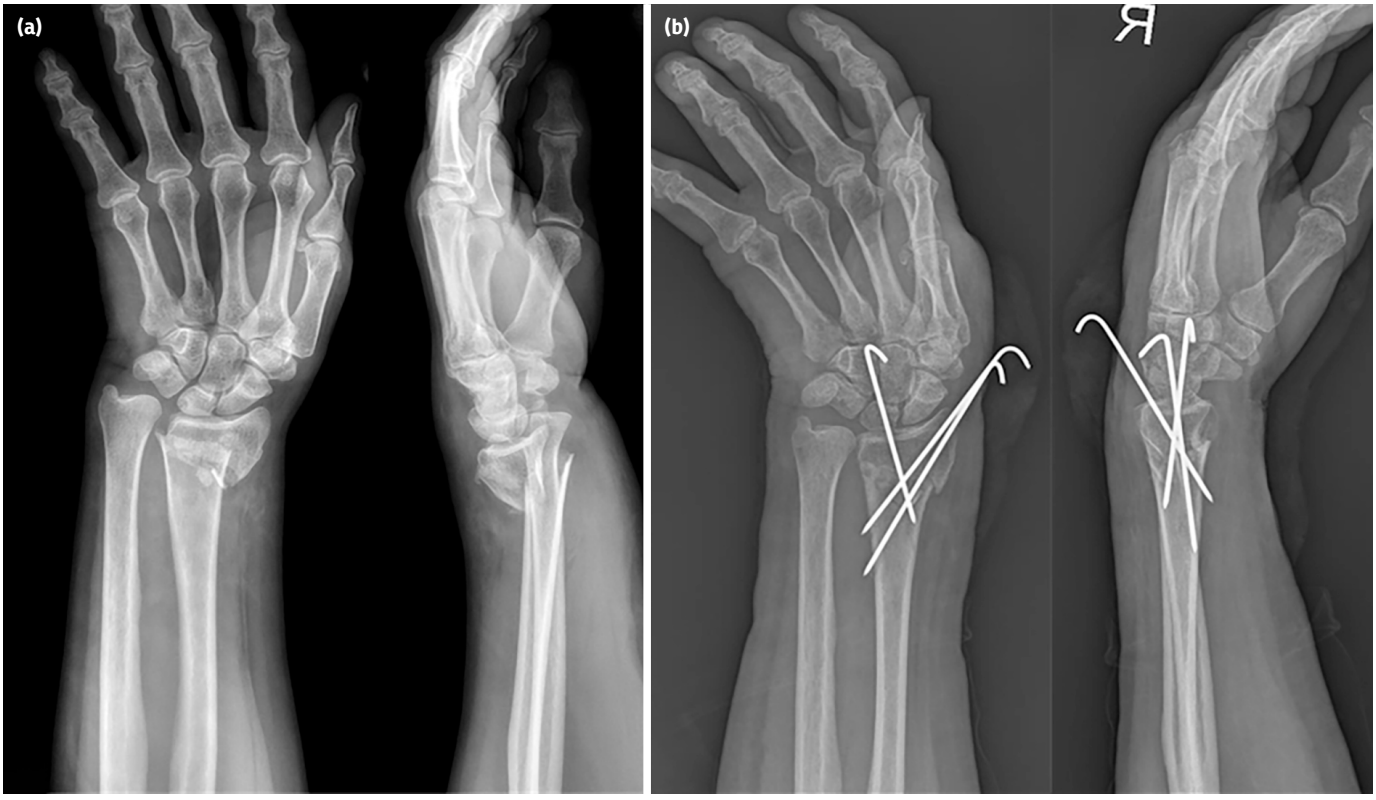


Figure 1. Percutaneous kirschner wire fixation following closed reduction. **(a)** Preoperative posteroanterior and lateral wrist radiographs demonstrating an extra-articular distal radius fracture prior to intervention. **(b)** Postoperative posteroanterior and lateral views obtained after fluoroscopy-guided closed reduction and percutaneous Kirschner wire fixation, illustrating restoration of alignment and stable pin configuration

plate and screws (Fig. 2). Following fixation, the pronator quadratus was repaired, and all layers, including the skin, were closed anatomically. Incision sites were dressed, and sutures were removed at the 3-week follow-up.

Postoperative Management

After surgery, all patients received a volar short-arm splint with the wrist in a neutral position, allowing full mobility of the metacarpophalangeal joints. A standardized physiotherapy protocol was applied and demonstrated to all patients. Splinting was continued for three weeks, after which the splint was discontinued, and patients began active and passive wrist range-of-motion exercises. Although volar locking plate fixation may allow earlier mobilization due to its rigid construct, a uniform postoperative rehabilitation protocol was intentionally applied to both groups in order to minimize rehabilitation-related confounding and to allow a more objective comparison of the surgical techniques themselves. Patients were evaluated preoperatively and at postoperative week 1, week 3, week 6, month 3, month 6, and month 12.

For clinical and functional assessment, the disabilities of the arm, shoulder and hand (DASH) score, the patient-reported wrist evaluation (PRWE) score, and the visual analog scale (VAS; 0–10) for pain intensity were used.[9–12] DASH and PRWE scores were recorded at the final follow-up visit to reflect long-term functional outcomes, whereas VAS scores were assessed on postoperative day 1, at week 6, and at the final follow-up.

Radiological assessment was performed using standard posteroanterior and lateral wrist radiographs. Volar tilt, radial inclination, and radial height were measured. All radiographic measurements were obtained from radiographs acquired at the final follow-up visit, after fracture union had been confirmed. All radiographic parameters were independently evaluated by two researchers with clinical experience.

Postoperative outcomes were examined with respect to fracture union, fixation failure, pain, scar formation, limitations in wrist range of motion, tendon irritation or injury, and com-



Figure 2. Volar locking plate fixation after open reduction. **(a)** Preoperative posteroanterior and lateral wrist radiographs showing the distal radius fracture pattern before surgical exposure. **(b)** Postoperative posteroanterior and lateral radiographs following open reduction and volar locking plate fixation, demonstrating anatomic restoration with secure plate-screw construct

plications such as hematoma, swelling, superficial or deep infection, sensory deficits, or neurovascular injury.

Statistical Analysis

Data were analyzed using SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Shapiro–Wilk test. For normally distributed variables, the Student's t-test was applied, whereas the Mann–Whitney U test was used for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher's exact test when appropriate. A p-value <0.05 was considered statistically significant.

Ethical Consideration

Ethical clearance for this investigation was obtained from the Ethics Committee of University of Health Sciences, Istanbul Kanuni Sultan Suleyman Training and Research Hospital (No: 2025.09.226, dated 10.09.2025). All study procedures were carried out in accordance with the ethical standards of the Declaration of Helsinki.

RESULTS

A total of 62 patients who underwent surgical treatment for extra-articular distal radius fractures were included in the study. Of these, 24 (38.7%) were assigned to the PKW group (Group 1) and 38 (61.3%) to the VLP group (Group 2). Group 1 comprised 10 males and 14 females (41.7%/58.3%), while Group 2 included 15 males and 23 females (39.5%/60.5%). There was no significant difference in sex distribution between the groups (p=1.000). The mean age was 34.46±12.47 (18–64) years in the PKW group and 35.37±14.61 (18–65) years in the VLP group, with no statistically significant difference (p=0.931).

Regarding early postoperative care parameters, the length of hospital stay was significantly shorter in the PKW group. The

Table 1. Demographic and perioperative characteristics

Variable	PKW (n=24)	VLP (n=38)	Statistical test	p
Age (years)	34.46±12.47 (18–64)	35.37±14.61 (18–65)	Mann–Whitney U	0.931
Sex (Female/Male)	14/10	23 / 15	Chi-square	1.000
Length of hospital stay (days)	1.54±0.72 (1–3)	2.74±1.00 (1–5)	Mann–Whitney U	<0.001
Follow-up duration (months)	24.75±10.94 (12–48)	32.89±15.92 (12–67)	Mann–Whitney U	0.048

PKW: Percutaneous kirschner wire; VLP: Volar locking plate.

Table 2. Clinical and functional outcomes (VAS, DASH, PRWE)

Variable	PKW (n=24)	VLP (n=38)	Statistical test	p
Postoperative day-1 VAS	4.38 ± 1.24 (2–7)	5.76 ± 1.38 (3–8)	Mann–Whitney U	<0.001
Postoperative Week-6 VAS	1.83 ± 0.87 (0–3)	1.79 ± 0.93 (0–3)	Mann–Whitney U	0.884
Final follow-up VAS	0.71 ± 0.81 (0–2)	0.58 ± 0.72 (0–2)	Mann–Whitney U	0.565
DASH score	12.37 ± 12.38 (0–45.5)	16.44 ± 14.87 (0–50.9)	Mann–Whitney U	0.362
PRWE score	16.02 ± 11.39 (4–46)	20.39 ± 14.48 (4–54.5)	Mann–Whitney U	0.347

VAS: Visual analog scale; DASH: Disabilities of the arm, shoulder and hand; PRWE: Patient-reported wrist evaluation; PKW: Percutaneous Kirschner wire fixation; VLP: Volar locking plate

Table 3. Radiological outcomes

Variable	PKW (n=24)	VLP (n=38)	Statistical test	p
Volar tilt (°)	9.42±6.58 (0–26)	11.95±6.64 (0–28)	Student's t-test	0.148
Radial inclination (°)	21.33±4.78 (12–29)	21.18±4.34 (11–30)	Student's t-test	0.902
Radial height (mm)	13.39±2.41 (8.5–17.4)	12.31±3.19 (7.1–18.7)	Student's t-test	0.137

PKW: Percutaneous kirschner wire; VLP: Volar locking plate

mean duration of hospitalization was 1.54±0.72 (1–3) days in Group 1 compared with 2.74±1.00 (1–5) days in Group 2 ($p < 0.001$). The mean follow-up duration was 24.75±10.94 (12–48) months in the PKW group and 32.89±15.92 (12–67) months in the VLP group (Table 1).

Postoperative pain was assessed using the VAS. On postoperative day 1, VAS scores were 4.38±1.24 (2–7) in the PKW group and 5.76±1.38 (3–8) in the VLP group, demonstrating significantly higher early postoperative pain in the VLP cohort ($p<0.001$). By week 6, pain levels had markedly improved in both groups, with comparable scores (PKW: 1.83±0.87 [0–3]; VLP: 1.79±0.93 [0–3]; $p = 0.884$). At the final follow-up, VAS scores remained low in both treatment groups (PKW: 0.71±0.81 [0–2]; VLP: 0.58±0.72 [0–2]), and no significant difference was observed ($p=0.565$).

Functional outcomes were evaluated using DASH and PRWE scores. The mean DASH scores were 12.37 ± 12.38 (0–45.5) in the PKW group and 16.44±14.87 (0–50.9) in the VLP group. The corresponding PRWE scores were 16.02±11.39 (4–46) and 20.39±14.48 (4–54.5), respectively. No statistically significant differences were observed between the groups in either DASH or PRWE scores (DASH, $p = 0.362$; PRWE, $p=0.347$) (Table 2).

Radiological evaluation demonstrated comparable outcomes between groups in terms of volar tilt, radial inclination, and radial height. The mean volar tilt was 9.42±6.58 (0–26)° in Group 1 and 11.95±6.64 (0–28)° in Group 2; radial inclination was 21.33 ± 4.78 (12–29)° and 21.18±4.34 (11–30)°, respectively. Radial height measured 13.39±2.41 (8.5–17.4) mm in the PKW group and 12.31±3.19 (7.1–18.7) mm in the VLP group. None of these radiographic parameters differed significantly between the groups (volar tilt, $p=0.148$; radial inclination, $p=0.902$; radial height, $p=0.137$) (Table 3).

No patient required secondary surgery due to nonunion during follow-up. Two patients (8%) in Group 1 developed superficial pin-tract infections, while five patients (13%) in Group 2 experienced superficial incisional site infections; all resolved with oral antibiotic therapy.

No cases of implant failure were observed during follow-up. Postoperative complications such as hematoma, swelling, sen-

sory deficits, tendon injury, or neurovascular damage were not encountered in any patient. Hypertrophic scarring occurred only in Group 2 and was identified in three patients (8%). No patient reported severe or functionally significant long-term wrist motion limitation during routine clinical follow-up.

In Group 1, tendon irritation associated with thumb movement—likely attributable to radial styloid-based pin placement—was observed in four patients (17%); symptoms resolved following pin removal.

DISCUSSION

In this retrospective cohort study, we compared the clinical, functional, and radiological outcomes of closed reduction with percutaneous Kirschner wire fixation (PKW) and open reduction with volar locking plate (VLP) fixation in the treatment of extra-articular distal radius fractures. Our findings demonstrated comparable demographic characteristics between the two groups, allowing the treatment effect to be evaluated independently of demographic confounders. Moreover, both techniques yielded similar long-term clinical, functional, and radiological outcomes; however, PKW provided distinct advantages, including shorter hospital stays and lower levels of early postoperative pain.

In our study, VAS scores on postoperative day 1 were significantly lower in the PKW group, likely attributable to the absence of an incision and the more limited soft-tissue dissection required for this technique. By week 6 and at final follow-up, pain levels converged, with both groups exhibiting similarly low scores. Consistent with our results, Peng et al.[13] reported in their meta-analysis that although small early differences may exist between VLP and PKW, long-term pain outcomes are largely comparable. Conversely, Wretö et al.[14] observed statistically lower long-term pain scores in patients treated with percutaneous K-wires compared with VLP, although they noted that the clinical significance of this difference remained questionable. Taken together, our findings support the notion that while the minimally invasive nature of PKW offers an early postoperative pain advantage, pain levels in both techniques decline over time to similarly low values.

The absence of significant differences in DASH and PRWE scores between the groups aligns strongly with the current literature. A large multicenter study reported no difference in one-year patient-reported functional outcomes between K-wire fixation and volar plating, while emphasizing the lower cost and technical simplicity of K-wire fixation.[15] Similarly, the meta-analysis by Peng et al.[13] found that although VLP may yield slightly lower DASH scores, it is associated with longer operative times, and no differences were identified between the two techniques in PRWE outcomes. In another meta-analysis, Chaudhry et al.[16] reported marginally better DASH scores in VLP-treated patients compared with K-wire fixation; yet, these differences were small and considered unlikely to be clinically meaningful. A more recent five-year comparative series likewise demonstrated no significant differences in functional scores such as DASH and PRWE between percutaneous K-wire fixation and VLP, confirming that both techniques provide satisfactory functional outcomes.[17] Although VLP remains widely preferred due to its perceived advantages in stability, early motion, and restoration of anatomy,[17–20] biomechanical data from synthetic composite bone models suggest that K-wire configuration has a substantial impact on stability and that minimally invasive constructs can achieve sufficient strength when properly executed.[21] Despite being derived from a different anatomical region, these biomechanical principles help explain why PKW can provide adequate stability and favorable clinical results in distal radius fractures. Our finding of comparable functional outcomes supports the conclusion that a minimally invasive approach can, in appropriately selected cases, achieve long-term results equivalent to open surgery without the need for more aggressive intervention.

The relationship between radiological parameters—volar tilt, radial inclination, and radial height—and functional outcomes in distal radius fractures has been widely debated. A systematic review and meta-analysis evaluating the association between radiological alignment and patient-reported outcomes found that unacceptable reductions, such as marked dorsal angulation and increased ulnar variance, were linked with poorer functional scores; however, these differences often remained below the threshold of minimal clinical significance.[22] Similarly, a multicenter study reported statistically significant differences in volar tilt between treatment groups without corresponding differences in clinical and functional outcomes.[23] Another meta-analysis comparing PKW and VLP found no significant differences in radiographic parameters between the two techniques.[16] In line with these findings, our study demonstrated comparable and acceptable radiological values in both groups, indicating that anatomical restoration can be achieved effectively with either PKW or VLP.

The strengths of this study include its exclusive focus on extra-articular (A2–A3) fractures, the use of a standardized surgical and rehabilitation protocol within a single center, and a minimum follow-up duration of 12 months. However, its retrospective nature, limited sample size, differences in follow-up duration, and lack of randomization represent key limitations. The subjective nature of patient-reported

outcomes should also be considered when interpreting the results. Moreover, objective functional parameters such as range of motion, grip strength, and return-to-work time were not quantitatively measured, which should be taken into account when interpreting the functional outcomes. Furthermore, although radiographic parameters were independently assessed by two experienced observers, inter- and intra-observer reliability analyses were not performed, which may have introduced a degree of measurement variability. Finally, group allocation was not randomized and was determined based on clinical judgment and surgeon preference, which may have introduced selection bias.

CONCLUSION

In conclusion, PKW and VLP provide comparable long-term outcomes in terms of pain, functional recovery, and radiological parameters in the management of extra-articular distal radius fractures. PKW, as a minimally invasive method, offers advantages such as reduced early postoperative pain and shorter hospital stays, making it a safe and effective option when used in appropriately selected patients. Larger prospective randomized studies are needed to provide more definitive guidance in treatment selection.

Disclosures

Ethics Committee Approval: The study was approved by the University of Health Sciences, Istanbul Kanuni Sultan Suleyman Training and Research Hospital Ethics Committee (No: 2025.09.226, Date: 10/09/2025).

Informed Consent: Informed consent was obtained from all participants.

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