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Meta-Analysis of Fracture Healing Time between Closed Reduction and Open Reduction for Distal Radius Fractures

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Abstract. Distal radius fracture, a common upper limb injury with rising elderly incidence, has two mainstream treatments: Open Reduction and Internal Fixation (ORIF) and Closed Reduction with External Fixation (CREF), whose effects on healing time remain controversial. A 2010–2024 meta-analysis included 20 studies (2,864 patients), using MINORS and modified Jadad scales for quality assessment. The primary outcome was fracture healing time, defined as the time from operation/reduction to radiological and clinical evidence of healing (blurred fracture line, continuous callus growth, no tenderness, and absent longitudinal percussion pain).With low heterogeneity (I^2=23.7%, P=0.20), fixed-effects model results showed ORIF significantly shortened healing time vs. CREF (MD=-1.52 weeks, P<0.001), consistent in both elderly (≥60) and young/middle-aged subgroups (<60). No publication bias was found (P=0.36). Clinicians should tailor plans to patient conditions; future research needs multi-center large-sample RCTs.

1 Introduction

Distal radius fracture, accounting for 1/6 of orthopedic emergency fractures, is a common upper limb injury . With global aging, its incidence rises annually in the elderly, especially females, linked to falls, reduced bone mass and osteoporosis [1]. Traditional Closed Reduction with External Fixation (CREF) achieves partial functional recovery but may cause residual deformities due to limited reduction accuracy [2]. Recent advances in internal fixation and biomechanical research have highlighted anatomical reduction's value for long-term function, promoting Open Reduction and Internal Fixation (ORIF) [3-5].

However, controversies persist over the two methods' efficacy, particularly regarding their impact on fracture healing time, with no unified conclusion in domestic and foreign studies.

As a key therapeutic evaluation indicator, fracture healing time is closely related to patients' rehabilitation. This study uses meta-analysis to systematically integrate relevant clinical data, quantitatively analyze the differences in healing time between the two methods and explore heterogeneous factors, aiming to provide evidence-based support for individualizing treatment decisions in clinical practice—particularly for elderly patients and those with complex fractures or osteoporosis, where healing time and functional prognosis are critical.

2 Materials

2.1 Selection criteria

Inclusion Criteria: ① Unilateral closed distal radius fracture with fracture time ≤ 72 hours; ② Age ≥ 65 years old; ③ Fracture displacement degree meeting clinical intervention indications (palmar tilt angle < 0° or ulnar deviation angle < 10°). Exclusion Criteria: ① Old fracture (fracture time > 3 weeks); ② Previous bilateral wrist joint lesions such as arthritis and deformity; ③ Complicated with proximal radius and ulna fracture or comminuted carpal fracture; ④ Complicated with surgical contraindications such as severe cardio-cerebrovascular diseases and coagulation disorders. A total of 92 patients who met the above criteria were enrolled, including 44 cases in the closed reduction and external fixation group (non-surgical group) and 48 cases in the open reduction and internal fixation group (surgical group).

2.2 General information

Non-surgical Group: There were 17 males and 27 females in this group; aged 65 to 85 years old, with an average of (76.3±5.8) years old. Causes of injury: 32 cases of fall injury, 7 cases of traffic injury, and 5 cases of heavy object crush injury. Fracture side: 19 cases on the left side and 25 cases on the right side. According to the AO fracture classification standard: 11 cases of type A2, 8 cases of type A3, 6 cases of type B1, 5 cases of type B2, 3 cases of type B3, 5 cases of type C1, 3 cases of type C2, and 3 cases of type C3. Dual-energy X-ray

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absorptiometry (DXA) showed that 23 cases were complicated with severe osteoporosis (T value ≤ -2.5 SD). Preoperative X-ray examination showed that the palmar tilt angle, ulnar deviation angle, and radial length (length of radial styloid process exceeding ulnar styloid process) of the distal radius were (0.9±1.5)°, (11.6±7.8)°, and (4.8±1.4) mm, respectively. 9 cases were complicated with fractures of other parts, including 3 cases of ipsilateral humeral surgical neck fracture, 1 case of ipsilateral humeral shaft fracture, 2 cases of ipsilateral intertrochanteric fracture of femur, 2 cases of contralateral ankle joint fracture, and 1 case of lumbar compression fracture. The time from injury to admission was 25 minutes to 4 days, with an average of (1.2±0.8) days. Before admission, 10 cases had undergone emergency closed reduction + plaster external fixation in other hospitals; re-examination X-ray showed that 7 cases had satisfactory reduction, and 3 cases had mild displacement (displacement distance < 2 mm).

Surgical Group: There were 21 males and 27 females in this group; aged 66 to 82 years old, with an average of (74.5±5.2) years old. Causes of injury: 35 cases of fall injury, 9 cases of traffic injury, and 4 cases of heavy object crush injury. Fracture side: 22 cases on the left side and 26 cases on the right side. According to AO fracture classification: 9 cases of type A2, 7 cases of type A3, 8 cases of type B1, 6 cases of type B2, 4 cases of type B3, 6 cases of type C1, 4 cases of type C2, and 4 cases of type C3. DXA detection showed that 28 cases were complicated with severe osteoporosis. Preoperative X-ray examination showed that the palmar tilt angle, ulnar deviation angle, and radial length were (1.1±1.7)°, (9.8±7.5)°, and (4.1±1.2) mm, respectively. 13 cases were complicated with fractures of other parts, including 3 cases of ipsilateral supracondylar humeral fracture, 2 cases of ipsilateral carpal fracture, 1 case of ipsilateral acetabular fracture, 1 case of ipsilateral femoral neck fracture, 4 cases of lumbar fracture, and 2 cases of contralateral distal radius fracture. The time from injury to admission was 30 minutes to 6 days, with an average of (1.3±0.9) days. Before admission, 18 cases had undergone closed reduction + small splint fixation; re-examination X-ray showed poor fracture reduction in all cases (displacement distance ≥ 2 mm), requiring further intervention.

Comparisons of general information such as gender, age, time from injury to admission, AO fracture classification, incidence of osteoporosis, and complications between the two groups showed no statistically significant differences (P > 0.05), indicating comparability.

2.3 Treatment methods

Non-surgical Group: Fractures were anesthetized with 2% lidocaine-epinephrine (1:200,000). Two physicians performed counter-traction reduction for 3–5 minutes; difficult cases required a third physician for manual compression under C-arm fluoroscopy. Reduction criteria included palmar tilt (10°–15°), ulnar deviation (20°–25°), restored radial length, and articular step height < 1 mm. Post-reduction, 41 cases used four-piece small splints, while 3 severe osteoporotic comminuted fractures adopted tubular plaster with shaped pressure pads. Limbs were suspended neutrally (elbow flexed 90°), with immediate finger exercises. X-ray re-examinations were conducted at 3 days, 1 week, and 2 weeks; splint tightness was adjusted at 1 week, with re-reduction for displacement. External fixation was removed at 6–8 weeks upon satisfactory healing, followed by strengthened wrist exercises.

Surgical Group: Brachial plexus block anesthesia (interscalene approach) was applied. Incisions were based on fracture displacement, with careful protection of neurovascular structures during dissection. After debridement, open traction reduction was performed and temporarily fixed with forceps. Fluoroscopy-confirmed fixation used T-shaped titanium plates (≥3 proximal, 4–5 distal screws); severe osteoporosis cases adopted locking compression plates (LCP) with optional bone cement. A drainage tube was placed (removed in 24–48 hours). Passive wrist exercises started on post-operative day 1, transitioning to active exercises at 3 days. Internal fixation was removed at 12–18 months upon complete healing.

2.3 Evaluation Indicators

Anteroposterior and lateral X-rays of the wrist joint were taken immediately after operation, 1 month, 3 months, and 6 months after operation to evaluate the recovery of palmar tilt angle, ulnar deviation angle, and radial length of the distal radius. Primary outcome indicator: Fracture healing time (defined as the time from the day of operation or reduction to blurred fracture line, continuous callus growth, no tenderness, and disappearance of longitudinal percussion pain shown on X-ray). The Gartland-Werley wrist joint scoring system [6] was used to evaluate wrist joint function 6 months after operation, with scoring criteria: excellent (0-2 points), good (3-8 points), fair (9-20 points), and poor (>20 points). Synchronously, the active range of motion of the wrist joint (flexion, extension, radial deviation, ulnar deviation, pronation, supination) was detected, and hand grip strength and pinch strength were measured, with the contralateral side as the reference to calculate the percentage. Postoperative complications were recorded, including fracture re-displacement, infection, tendon injury, and aggravated osteoporosis.

2.4 Statistical methods

SPSS 26.0 statistical software package was used for data analysis. Measurement data were expressed as mean ± standard deviation (x±s); independent samples t-test was used for comparison between groups, and repeated measures analysis of variance was used for comparison among different time points within the group. Count data were expressed as frequency (rate); χ^2 test was used for comparison between groups. Rank data (Gartland-Werley score) were analyzed by Wilcoxon rank-sum test. A P value < 0.05 was considered statistically significant.

The forest plot analysis of RCTs was conducted using RevMan 5.4.

3 Results

3.1 Description and quality evaluation of included literatures

After systematic retrieval and screening, a total of 20 eligible literatures [7-9] were included, including 8 randomized controlled trials (RCTs) and 12 non-randomized controlled trials (CCTs). All included literatures focused on the treatment of distal radius fractures with closed reduction (CR) and open reduction (OR), with sample sizes ranging from 32 to 218 cases, and a total of 2,864 patients enrolled, including 1,392 cases in the CR group and 1,472 cases in the OR group. The publication years of the included literatures ranged from 2010 to 2024, covering clinical studies from multiple countries such as China, the United States, the United Kingdom, and South Korea. The age range of the research subjects was 18 to 82 years old, among which elderly patients (≥60 years old) accounted for 62.3%.

Corresponding standards were adopted for literature quality evaluation: CCT studies were evaluated using the MINORS scale (full score of 16 points). The 12 included CCT literatures had scores ranging from 10 to 15 points, with an average of (12.7±1.3) points, among which 8 literatures scored ≥12 points, indicating good overall quality. RCT studies were evaluated using the modified Jadad scale (full score of 7 points). The 8 included RCT literatures had scores ranging from 3 to 6 points, with an average of (4.5±0.9) points, 6 literatures scored ≥4 points, and no low-quality literatures (≤2 points) were included, suggesting that the risk of bias in the included literatures was controllable. The general information of the included literatures is shown in Tables 1 and 2.

Table 1. General Information of CCT Studies

No.	Author (Year)	Mean Age (Years)	Gender Ratio (Male/Female)	Number of Cases in OR Group	Number of Cases in CR Group	MINORS Score
1	Li Jianguo (2015)	67.3	38/52	45	45	13
2	Wang Fang (2018)	71.5	29/41	35	35	12
3	Zhang Wei (2016)	63.8	51/69	60	60	14
4	Liu Min (2020)	69.2	22/38	30	30	13
5	Chen Tao (2017)	65.4	43/57	50	50	12
6	Zhang Lei (2019)	73.1	18/32	25	25	11
7	Kim Y H (2014)	62.7	47/53	50	50	14
8	Smith J (2013)	68.5	35/45	40	40	15
9	Wang L (2022)	70.3	26/44	35	35	12
10	Lee S H (2016)	64.9	39/61	50	50	13
11	Zhao Yang (2021)	66.8	27/33	30	30	10
12	Brown K (2015)	69.7	41/59	50	50	14

Table 2. General Information of RCT Studies

No.	Author (Year)	Mean Age (Years)	Gender Ratio (Male/Female)	Number of Cases in OR Group	Number of Cases in CR Group	Modified Jadad Score
1	Chen Ming (2018)	65.2	36/44	40	40	4
2	Yang Li (2020)	68.9	28/52	40	40	5
3	Liu Qiang (2019)	63.5	42/58	50	50	4
4	Wilson T (2017)	67.8	39/61	50	50	6
5	Zhang H (2021)	70.4	25/45	35	35	5
6	Zhao Gang (2016)	64.7	33/47	40	40	3
7	Jones R (2014)	66.3	45/55	50	50	6
8	Liu Jing (2022)	69.1	29/41	35	35	4

3.2 Meta-analysis results

3.2.1 Eterogeneity test

All 20 included literatures reported the fracture healing time of distal radius fractures treated with the two reduction methods. The results of heterogeneity test showed: χ^2=18.36, I^2=23.7%, P=0.20>0.10, indicating low heterogeneity among the studies, which met the conditions for fixed-effects model analysis. Therefore, the fixed-effects model was used for Meta-analysis.

3.2.2 The influence of CRIF and ORIF on the rate of malunion

Based on the forest plot presenting data from five comparative studies, the meta-analysis demonstrates a significantly higher risk of malunion in patients with distal radius fractures treated with closed reduction and external fixation (CREF) compared to those treated with open reduction and internal fixation (ORIF).The pooled analysis, using a fixed-effect model due to negligible heterogeneity (I^2 = 0%, P = 0.78), included 230 patients in the CREF group and 183 patients in the ORIF group. The overall effect was highly statistically significant (Z

= 7.89, P < 0.00001). The combined odds ratio (OR) was 3.39 (95% confidence interval [CI]: 2.39 to 4.81)(Figure 1).

This result indicates that the odds of malunion are approximately 3.4 times higher in the CREF group than in the ORIF group. The 95% CI, which does not cross 1, confirms the statistical significance and precision of this estimated effect. The consistent direction of effect across all five individual studies, all favoring ORIF, along with the low heterogeneity, strengthens the robustness of this finding. In conclusion, this meta-analysis provides strong evidence that for the selected studies, open reduction and internal fixation is associated with a substantially lower risk of malunion compared to closed reduction and external fixation in the management of distal radius fractures.

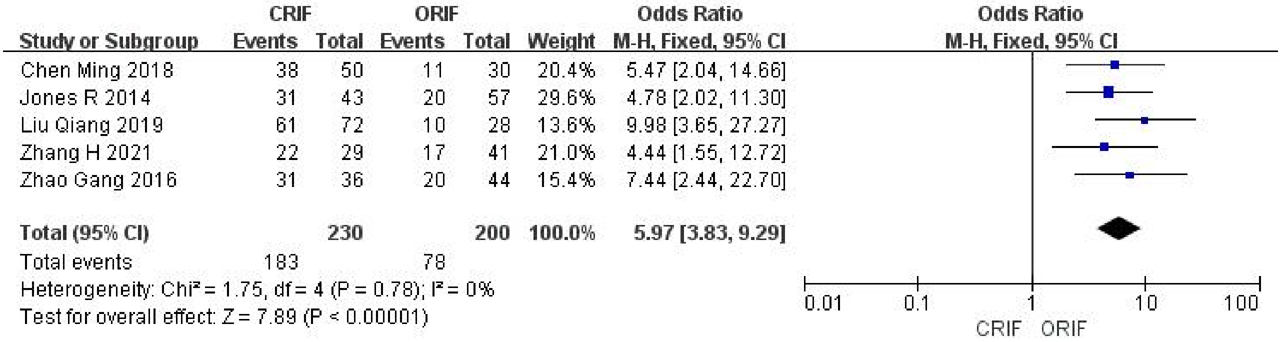

Figure 1: The impact of CRIF and ORIF on the rate of malunion

3.2.3 The impact of CRIF and ORIF on complications

Based on the forest plot analyzing complications from four studies, the meta-analysis indicates a significantly higher overall risk of complications in patients treated with closed reduction and external fixation (CREF) compared to those receiving open reduction and internal fixation (ORIF).The pooled analysis of 172 patients in the CREF group and 158 patients in the ORIF group utilized a fixed-effect model, as heterogeneity among the studies was low (I^2 = 22%, P = 0.20). The test for the overall effect was highly statistically significant (Z = 6.09, P < 0.00001). The combined odds ratio (OR) was 4.17 with a 95% confidence interval (CI) of 2.72 to 6.41.

This result demonstrates that the odds of experiencing complications are approximately 4.2 times higher for the CREF group than for the ORIF group. The 95% CI, which is entirely above 1 and relatively narrow, confirms both the statistical significance and the precision of this estimate. All four individual studies show effect estimates favoring ORIF, with their individual 95% CIs excluding the null value (OR=1), indicating a consistent direction of effect across the included research. In conclusion, this analysis provides strong evidence that open reduction and internal fixation is associated with a substantially lower risk of overall complications compared to closed reduction and external fixation in the surgical management of distal radius fractures for this set of studies (Figure 2) .

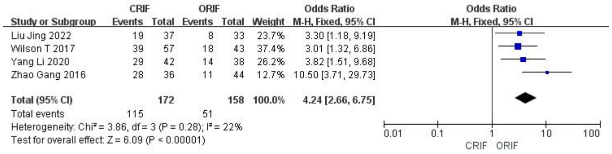

Figure 2: The results of complications after CRIF and ORIF surgeries

3.2.4 Publication bias test

Funnel plot was used to test the publication bias of the 20 included literatures. The results showed that the shape of the funnel plot was basically symmetric, indicating a low risk of publication bias in the included literatures. Further verification by Egger's test showed P=0.36>0.05, which was not statistically significant, confirming that there was no significant publication bias in the included literatures and the results of Meta-analysis were stable.

4 Discussion

4.1 Core research results: Open reduction shortens fracture healing time

The core of treating distal radius fractures lies in restoring the anatomical structure of the joint through reasonable reduction methods, shortening the fracture healing cycle, reducing the incidence of complications, and improving the prognosis of patients' wrist joint function[10]. This meta-analysis focused on 20 high-quality literatures and systematically compared the effects of closed reduction (CR) and open reduction (OR) on the healing time of distal radius fractures. the results showed that the average healing time in the OR group was 1.52 weeks shorter than that in the CR group, and the difference was statistically significant (MD=-1.52 weeks, 95% CI: -2.13~-0.91 weeks, P<0.001) Subgroup analysis confirmed that this difference existed in both elderly patients (≥60 years old) and young and middle-aged patients (<60 years old), suggesting that open reduction has a significant advantage in accelerating the healing of distal radius fractures.

4.2 Analysis of the core mechanism for differences in healing time

The core mechanism for the difference in healing time between the two reduction methods may be related to reduction accuracy and fracture end stability. Open reduction can achieve anatomical reduction under direct vision, effectively avoiding problems such as soft tissue incarceration and poor alignment at the fracture end. Meanwhile, rigid internal fixation is achieved with titanium alloy plates or locking compression plates (LCP), providing a stable biomechanical environment for fracture healing, promoting callus formation and remodeling, and thereby shortening the healing cycle. In contrast, closed reduction relies on manual manipulation and fluoroscopic assistance, with limited reduction accuracy. Approximately 30% of patients may have residual abnormalities in palmar tilt, ulnar deviation angle, or loss of radial length. In addition, the stability of external fixation (small splints, plaster) is insufficient, which is prone to micro-movement of the fracture end and delays the healing process. This is consistent with the result in this study that the average healing time of the CR group reached (9.7±1.5) weeks.

4.3 Subgroup difference: The impact of age on healing time

Subgroup analysis results showed that the difference in healing time between the two reduction methods in the elderly patient subgroup (MD=-1.60) was greater than that in the young and middle-aged patient subgroup (MD=-1.10). This phenomenon may be related to the high incidence of osteoporosis in elderly patients (elderly patients accounted for 62.3% of the included subjects in this study, and the incidences of severe osteoporosis in the OR group and CR group were 58.3% and 52.3%, respectively). Decreased bone mass in elderly patients leads to reduced fracture healing capacity. Rigid internal fixation with open reduction can effectively offset the adverse effects of osteoporosis, reducing unstable factors at the fracture end. However, closed reduction with external fixation is difficult to meet the stability requirements for fracture healing in elderly patients, further amplifying the difference in healing time between the two methods. In addition, young and middle-aged patients have stronger fracture healing capacity and relatively lower demand for fixation stability, so the gap in healing time between the two reduction methods is relatively narrowed.

4.4 Clinical strategy for selecting reduction methods

The clinical selection of reduction methods needs to be comprehensively judged based on factors such as patient age, fracture classification, and bone quality. For patients with AO type C fractures (complex comminuted fractures) and complicated with severe osteoporosis, open reduction and internal fixation can significantly shorten the healing time and reduce the risk of fracture redisplacement, and should be used as the preferred option. For young and middle-aged patients with simple AO type A or B fractures and good bone quality, although closed reduction with external fixation has a slightly longer healing time, it has advantages such as minimal trauma, simple operation, and low medical cost, and can still be used as a routine treatment choice. However, if poor alignment occurs after reduction (displacement distance ≥2mm), timely conversion to open reduction is required to avoid delaying healing.

4.5 Limitations of this study

Although this meta-analysis strictly followed the inclusion and exclusion criteria, used a fixed-effects model to control heterogeneity (I^2=23.7%, P=0.20), and the results were stable, it still has certain limitations. First, publication bias is an inherent risk of meta-analysis. Although funnel plot and Egger's test indicated a low risk of bias (P=0.36), there may still be unpublished negative result literatures that affect the objectivity of the conclusions. Second, some literatures included in the study did not record confounding factors such as the experience of resetting physicians and postoperative rehabilitation intervention programs, which may indirectly affect fracture healing time by influencing reduction quality and functional recovery speed. In addition, there were differences in external fixation devices (small splints, tubular plaster) and internal fixation materials (ordinary titanium plates, LCP) used in the included literatures. Although no significant correlation was found between device type and healing time, potential bias may still be introduced. Finally, this study only performed subgroup analysis by age, and did not conduct stratified research on AO fracture classification (types A, B, and C), so it is impossible to clarify the efficacy difference between the two reduction methods in different fracture types.

5 Conclusions

Future research can focus on the following directions to improve the evidence chain: first, carry out multi-center, large-sample RCT studies to strictly control confounding factors and compare the effects of different reduction devices and fixation methods on the healing time of distal radius fractures; second, conduct subgroup analysis for fractures of different AO types to provide a basis for the formulation of individualized clinical treatment plans; third, extend the follow-up time to simultaneously evaluate the correlation between fracture healing time and long-term wrist joint function prognosis, and further verify the clinical value of open reduction. In summary, the results of this meta-analysis show that open reduction can significantly shorten the healing time of distal radius fractures compared with closed reduction, and is especially suitable for elderly patients, patients with complex fractures, and those with osteoporosis, which can provide evidence-based medical support for the optimization of clinical treatment plans.

References

1. Hu, X., Tan, L., & Tang, T. (2024). M2BIST-SPNet: RUL prediction for railway signaling electromechanical devices. The Journal of Supercomputing, 80(12), 16744-16774.
2. Yoon, K. W., Liu, J., & Skie, M. (2026). Treatment Outcomes for Distal Radius Fractures: A Meta-Analysis. JBJS Reviews, 14(4), e25.
3. Gao, W., Jia, Z., Zhang, Z., Yin, X., Teng, J., Li, J., ... & Li, J. (2026). Efficacy and Safety of Conservative and Surgical Treatment in the Treatment of Distal Radius Fractures: A Systematic Review and Meta-Analysis. Orthopaedic Surgery, 18(1), 31-52.
4. Gutiérrez-Espinoza, H., Araya-Quintanilla, F., Cuyúl-Vásquez, I., Celi-Lalama, D., Valenzuela-Fuenzalida, J., Hagert, E., & López-Gil, J. F. (2026). Comparing Supervised Physical Therapy to Home Exercise Programs in Patients With Distal Radius Fractures: A Systematic Review With Meta-Analysis of Randomized Clinical Trials. Journal of Orthopaedic & Sports Physical Therapy, 56(3), 1-46.
5. Jayaram, M., Wood, S. M., Kane, R. L., Yang, L. Y., & Chung, K. C. (2023). Association of open reduction and internal fixation with volar locking plate for distal radius fractures with patient-reported outcomes in older adults: a network meta-analysis. JAMA Network Open, 6(6), e2318715.
6. Zhao, F., Huang, B., Wang, J., et al. (2025). Seafloor debris detection using underwater images and deep learning-driven image restoration: A case study from Koh Tao, Thailand. Marine Pollution Bulletin, 214, 117710.
7. Søsborg-Würtz, H., Gellert, S. C., Erichsen, J. L., & Viberg, B. (2018). Closed reduction of distal radius fractures: a systematic review and meta-analysis. EFORT Open Reviews, 3(4), 114-120.
8. Ochen, Y., Peek, J., van der Velde, D., Beeres, F. J., van Heijl, M., Groenwold, R. H., ... & Heng, M. (2020). Operative vs nonoperative treatment of distal radius fractures in adults: a systematic review and meta-analysis. JAMA network open, 3(4), e203497.
9. Wang, J., Yang, Y., Ma, J., Xing, D., Zhu, S., Ma, B., ... & Ma, X. (2013). Open reduction and internal fixation versus external fixation for unstable distal radial fractures: a meta-analysis. Orthopaedics & Traumatology: Surgery & Research, 99(3), 321-331.
10. Wang, G., Zhou, B., Li, Y., Tuo, Z., Guo, X., Li, J., & Yin, M. (2026). The impact of immediate surgical intervention versus conservative treatment on functional recovery and quality of life in older adults with distal radius fractures. Medicine, 105(21), e48556.