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Systematic review

Predictors of loss of alignment after emergency department reduction and casting of distal radius fractures in adults: A Systematic Review

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Abstract

Background: Loss of alignment after closed reduction and casting of distal radius fractures is a frequent reason for repeat imaging, delayed surgery, and malunion. Early recognition of fractures at greatest risk of redisplacement is important after emergency department management. In this study we aimed to analyze adult original articles on patient, fracture, radiographic, reduction, and casting factors associated with loss of alignment after closed reduction and immobilization. **Methods:** A PRISMA-aligned review framework covered PubMed, Scopus, Web of Science Core Collection, and Cochrane CENTRAL from inception to August 2026. Eligible

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studies enrolled adults with acute distal radius fractures managed nonoperatively after closed reduction and reported serial radiographic alignment or redisplacement. Pediatric studies, operative cohorts, case reports, and studies lacking post-reduction follow-up were excluded. **Results:** We include 18 adult original studies. Increasing age, radial shortening or positive ulnar variance, severe initial displacement, comminution, and failure to restore the volar cortex were the most recurrent predictors. Post-reduction alignment carried a prognostic value. Loss of alignment occurred frequently in cohorts, although definitions, radiographic thresholds, fracture patterns, and timing of follow-up varied substantially among individual studies. Traditional composite rules showed limited external discrimination. **Conclusion:** Risk prediction is strongest when baseline fracture severity is combined with immediate post-reduction radiographic quality rather than relying on a single historical criterion.

Keywords: distal radius fracture; closed reduction; cast immobilization; redisplacement; loss of reduction; fracture instability; emergency department; prognostic factors

Introduction

Distal radius fractures (DRF) are major component of adult hand and forearm trauma and contribute to emergency care workloads, with radius and ulna fractures forming the largest forearm-fracture category in national ambulatory data (1). Their epidemiology shows a prominent burden in older adults, in women, with a younger high-energy injury group, creating a broad population in whom treatment goals and tolerance of residual deformity differ (2). Unstable DRF lack a uniform research definition, with secondary displacement after adequate reduction, Lafontaine criteria, irreducibility, and selected AO patterns all used as instability constructs (3).

A prior systematic review of prognostic studies found that increasing age, initial shortening, volar comminution, loss of radial inclination, a volar hook finding, and several severe fracture classifications were associated with secondary displacement (4). Closed reduction technique affect the immediate radiographic result, and a systematic review comparing finger-trap and manual traction found different strengths for correction of shortening and dorsal tilt (5). Contemporary AAOS/ASSH guidance places post-reduction radiographic parameters and patient age in factors relevant to treatment selection (6).

Recent study has renewed interest in conservative care because non-surgically treated adults achieve useful functional recovery despite a complication burden (7). A 2026 prognostic-factor systematic review and meta-analysis of 30 studies and 7,495 fractures reported a weighted loss-of-reduction proportion of 43.4%, with high-certainty multivariable evidence for age above 60 years and greater prereduction positive ulnar variance, plus moderate-certainty associations for dorsal comminution, failure to restore volar cortical alignment, marked dorsal angulation.

The present review focused on adult primary studies evaluating loss of acceptable alignment after closed reduction and cast or splint immobilization of DRFs. We examined demographic variables, fracture morphology, prereduction measurements, reduction quality, cortical restoration, and cast-related measures as predictors of secondary displacement during nonoperative follow-up.

30/08/2026

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Methods

This prognostic-factor systematic review was structured according to PRISMA 2020 and used a prespecified PICOTS framework. The population was adults aged 18 years or older with acute DRFs treated by closed reduction followed by cast or splint immobilization. Eligible predictors included demographic characteristics, fracture morphology, prereduction radiographic measurements, immediate post-reduction alignment, cortical restoration, and casting measures. The primary outcome was secondary loss of acceptable radiographic alignment during nonoperative follow-up, including redisplacement, recurrent deformity, radiographic malunion, or treatment escalation triggered by loss of reduction.

The search framework covered PubMed, Scopus, Web of Science Core Collection, and the Cochrane Central Register of Controlled Trials from inception through August 2026. Search concepts combined terms for "distal radius fracture" or "Colles fracture" with "closed reduction," "manipulation," "cast," "splint," "redisplacement," "loss of reduction," "secondary displacement," "alignment," "instability," "predictor," and "risk factor," using database-specific controlled vocabulary and syntax. Reference lists of eligible studies and relevant systematic reviews were checked to identify additional adult primary studies. Bibliographic details and eligibility of the studies retained in this evidence draft were verified against PubMed or publisher records and cross-indexed sources.

Original studies were eligible when adult patients underwent closed reduction and external immobilization and serial post-reduction radiographs permitted assessment of alignment over time. Mixed cohorts were retained only when adult reduced-fracture data were separable, while pediatric cohorts, primarily operative series, postoperative fixation failure, biomechanical studies, case reports, and reviews were excluded. Titles and abstracts were screened against these criteria, followed by full-text assessment of eligible records. Extraction fields comprised study design, sample size, fracture pattern, reduction pathway, immobilization method, follow-up timing, definition of re-displacement, candidate predictors, adjusted estimates, discrimination statistics, and principal findings.

Prognostic-factor studies were appraised in QUIPS domains, including participation, attrition, prognostic-factor measurement, outcome measurement, confounding, and statistical analysis. Prediction-model development or validation studies were additionally considered against PROBAST domains, with particular attention to overfitting, internal validation, predictor handling, and outcome definition. Narrative synthesis was prioritized because definitions of unacceptable dorsal tilt, shortening, radial inclination, ulnar variance, and follow-up timing differed substantially between cohorts; predictor strength was judged from consistency, adjusted independence, replication, and clinical relevance.

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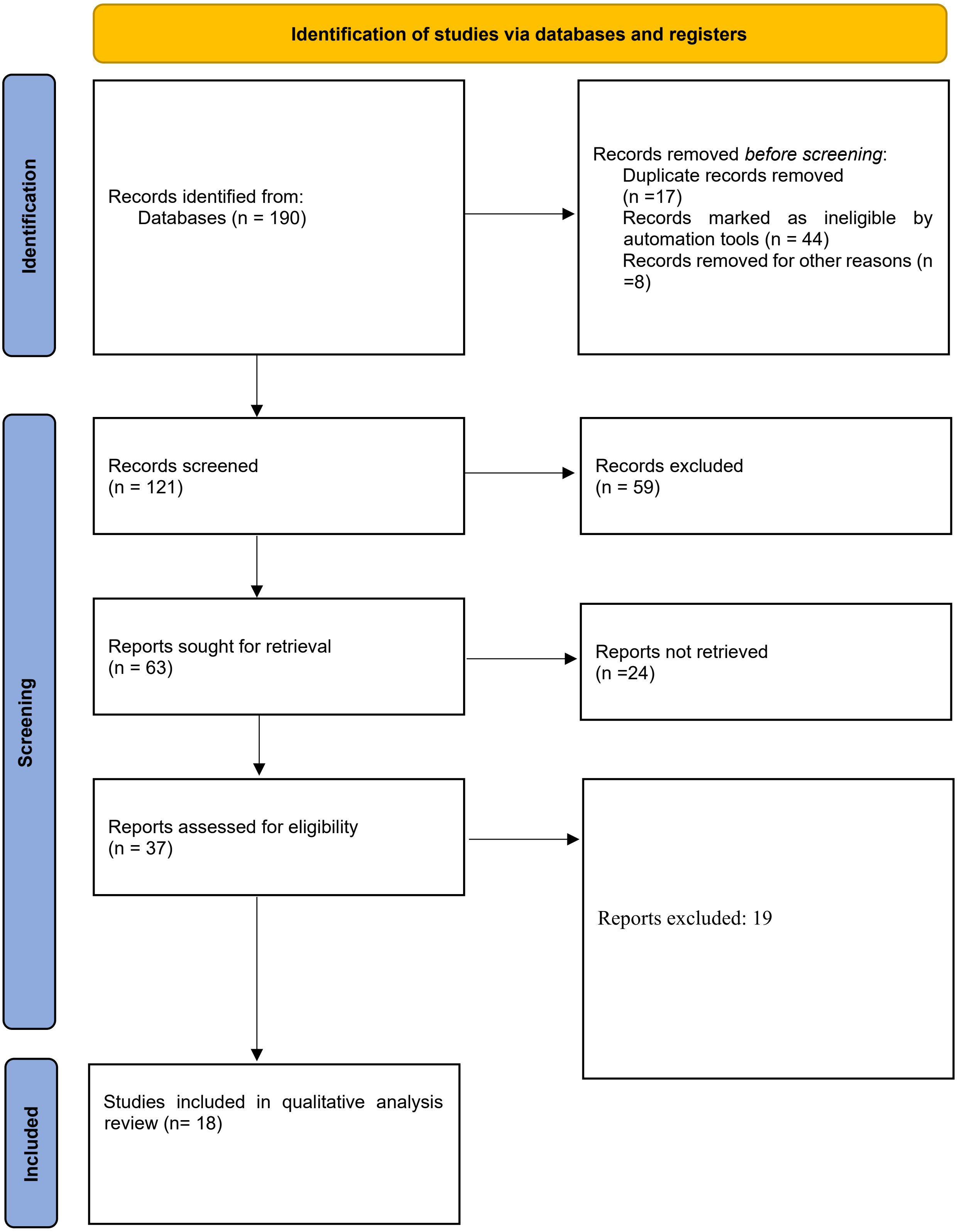
Fig 1: PRISMA flow chart



30/08/2026

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Results

Eighteen adult primary studies were retained in the synthesis, spanning 1989–2026 and covering prognostic rules, radiographic predictors, reduction quality, cast geometry, validation, and newer prediction models (9–26). A cohort of 112 fractures identified five clinical and radiographic features associated with instability after distal radius fracture reduction (9). In a study of 50 adults, increasing age was the only individual component of the Lafontaine criteria that reached statistical significance (10). Among 71 extra-articular fractures, radial shortening and dorsal tilt were associated with early failure, while increasing age was linked to later instability (11). Analysis of a large fracture database identified age, metaphyseal comminution, and ulnar variance as recurrent predictors of secondary displacement (12). In an adult emergency-department cohort, the degree of secondary displacement increased progressively with advancing age (13).

A cohort of 75 adults treated with emergency-department reduction found strong predictive performance for the three-point index (14). In another cohort of 157 adults, 92 experienced loss of reduction, with radial shortening, reduced radial inclination, and increasing age identified as important predictors (15). A separate study of 54 adults failed to demonstrate similarly strong predictive performance for the three-point index (16). Among 168 displaced distal radius fractures, restoration of the volar cortex and the quality of post-reduction alignment were associated with maintenance of final alignment (17). In a cohort of 132 adults managed with closed reduction, greater initial displacement predicted secondary displacement, while increasing age was associated with late redisplacement (18). Validation of the Edinburgh Wrist Calculator in 99 adults produced AUC values of 0.47 and 0.71 depending on the definition of unacceptable alignment applied (19). Another study involving 90 fractures identified increasing age, greater initial displacement, and intra-articular characteristics as predictors of displacement (20).

Recent adult cohorts show the prognostic importance of cortical support and residual shortening after reduction (21–26). Among 105 adults, progressively poorer restoration of the volar cortical hinge was associated with a greater likelihood of reintervention or malunion (21). In a cohort of 884 adults, including 563 cases of redisplacement, increasing age, AO/OTA fracture type, prereduction ulnar variance (22). Another study involving 274 adults reported a redisplacement rate of 39%, with the original Lafontaine score producing an AUROC of 0.65 (23). Among 172 adequately reduced fractures, 40% showed redisplacement at two weeks, while none of the three evaluated casting indices demonstrated a significant association with this outcome (24). A prediction model derived from 244 adults incorporated dorsal angulation, intra-articular involvement, ulnar variance, volar cortical restoration (25). In an emergency-department cohort, post-reduction palmar tilt, radial height, and overall reduction quality emerged as the strongest machine-learning predictors of radiographic outcome at six weeks (26).

Increasing age and radial shortening or positive ulnar variance were the most reproducible baseline predictors, with comminution and initial displacement adding fracture-severity information.

30/08/2026

Immediate post-reduction films added information through volar cortical restoration, residual shortening, tilt, radial height, and overall reduction quality. Cast-shape indices were the least reproducible predictor domain across adult cohorts.

Table 1. Characteristics and main findings of included original studies

Study	Sample; pathway	Main finding
Lafontaine et al., 1989 (9)	n=112; conservative	≥3 features indicated greater displacement.
Nesbitt et al., 2004 (10)	n=50; reduction/splint	Age was the only significant individual Lafontaine factor.
Leone et al., 2004 (11)	n=71; extra-articular	Shortening and dorsal tilt predicted early failure; age contributed later.
Mackenney et al., 2006 (12)	n=1,595; prospective database	Age, metaphyseal comminution, and ulnar variance were leading predictors.
Makhni et al., 2008 (13)	n=124; 74 reduced	Secondary displacement increased across older age groups.
Alemdaroğlu et al., 2010 (14)	n=75; ED reduction/cast	Three-point index and nonanatomic reduction predicted redisplacement.
Tahririan et al., 2013 (15)	n=157; reduction/plaster	92 lost reduction; shortening, inclination loss, and age were important.
Siddiqui et al., 2013 (16)	n=54; manipulation/cast	Three-point index lacked reliable predictive performance.
LaMartina et al., 2015 (17)	n=168; reduction/cast	Volar cortical restoration and post-reduction alignment predicted maintenance.
Jung et al., 2015 (18)	n=132; closed reduction/cast	Initial displacement predicted redisplacement; age related to late failure.
Walenkamp et al., 2018 (19)	n=99; validation	EWC AUC varied from 0.47 to 0.71 by threshold.
Mimura et al., 2021 (20)	n=90; casting	Age and original displacement predicted failure; cast measures were weaker.
Mathews et al., 2024 (21)	n=105; closed reduction	Poorer volar cortical hinge restoration tracked reintervention or malunion.
Zhao et al., 2024 (22)	n=884; nonsurgical reduction	63.7% redisplaced; age, AO/OTA type, and ulnar variance were independent.
Dissaneewate et al., 2025 (23)	n=274; reduction/immobilization	Redisplacement 39%; Lafontaine AUROC 0.65; age and shortening improved prediction.

Study	Sample; pathway	Main finding
Barvelink et al., 2025 (24)	n=172; reduced/circumferential cast	Redisplacement 40%; three casting indices were not associated.
Khajonvittayakul et al., 2025 (25)	n=244; closed reduction/cast	Pre- and post-reduction factors produced strong internal discrimination.
Taleghani et al., 2026 (26)	n=152; ED reduction	Post-reduction tilt, radial height, and reduction quality dominated (26).

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Discussion

After emergency-department reduction, the leading prognostic signals were age, radial shortening or positive ulnar variance, comminution, initial displacement, and reduction quality. The newest prognostic meta-analysis identified high-certainty multivariable evidence for age above 60 years and prereduction positive ulnar variance, with moderate-certainty associations for dorsal comminution, marked dorsal angulation, and failed volar cortical restoration (8). Instability is better represented as accumulated risk in patient characteristics, fracture morphology, and post-reduction mechanics than as one isolated feature (8,12,17,22,25,26).

Age was the most reproducible patient-level predictor in varying thresholds (10,12,13,15,18,20,22,23), it reflects part of the bone-quality and metaphyseal-collapse risk seen in fragility-pattern fractures (4,8,12). Ghodasra et al. studied 304 nonsurgically treated adults and found that lower second-metacarpal cortical percentage together with Lafontaine instability was associated with greater subsequent ulnar variance (27).

Fracture morphology is important without providing complete discrimination alone (9–12,18,20,22,23). The original Lafontaine rule combined five features, while later validations found uneven performance among individual components and modest discrimination of the composite score (9,10,23). Souza et al. examined initially nondisplaced or minimally displaced adult fractures and found dorsal comminution and age above 60 years associated with later loss of acceptable alignment (28).

The most actionable finding concerns the immediate post-reduction radiograph, with maintained alignment linked to restored volar cortical support and correction of residual shortening, ulnar variance, tilt, or radial height (17,21–26). LaMartina and Mathews emphasized the volar cortex, while Zhao, Khajonvittayakul, and Taleghani strengthened the role of quantitative post-reduction measurements in contemporary cohorts (17,21,22,25,26). This pattern supports close scrutiny of cortical apposition and residual deformity before discharge rather than risk classification from the injury film alone (17,21,25,26).

Casting indices showed the greatest inconsistency in adult studies (14,16,20,24). Alemdaroğlu reported high three-point-index performance, whereas Siddiqui and later cohorts did not reproduce a stable independent association for three-point, cast, or gap indices (14,16,20,24). Cast geometry therefore appears less dependable as a stand-alone prognostic measure than fracture severity and achieved reduction (20,24).

Prediction models were sensitive to outcome definitions and validation setting, showed by threshold-dependent Edinburgh Wrist Calculator performance and modest external discrimination of the Lafontaine criteria (19,23). Rodrigues et al. prospectively found stronger prediction from selected classifications and advanced age than from the Lafontaine criteria (29). Newer models integrating pre-reduction and post-reduction variables achieved stronger discrimination, although external validation is necessary before routine adoption across emergency departments (25,26).

30/08/2026

Interpretation is limited by heterogeneous definitions of redisplacement, fracture patterns, immobilization methods, follow-up intervals, and adjustment strategies. Several cohorts were retrospective or restricted to selected fracture types, and acceptable radiographic thresholds differed among institutions, limiting direct pooling. The adult-only focus increases relevance to emergency reduction practice while excluding pediatric studies with different remodeling biology and treatment thresholds.

Conclusion

Loss of alignment after closed reduction and casting of adult DRFs is best predicted through combined assessment of patient age, initial fracture severity, radial shortening or positive ulnar variance, comminution, and immediate post-reduction quality. Restoration of the volar cortex and correction of residual shortening provide particularly useful post-reduction information. Historical composite rules show limited external discrimination, and adult cast indices lack consistent reproducibility. Emergency-department risk stratification is therefore strongest when injury radiographs are reassessed together with immediate post-reduction films. High-risk reductions merit early orthopaedic review and close radiographic surveillance during the first weeks of immobilization after initial treatment.

List of abbreviations used

AAOS: American Academy of Orthopaedic Surgeons
ASSH: American Society for Surgery of the Hand
AO/OTA: AO Foundation/Orthopaedic Trauma Association classification
AUC: Area under the receiver operating characteristic curve
AUROC: Area under the receiver operating characteristic curve
CENTRAL: Cochrane Central Register of Controlled Trials
DRF: Distal radius fracture
ED: Emergency department
EWC: Edinburgh Wrist Calculator
PICOTS: Population, Index prognostic factor, Comparator, Outcome, Timing, Setting
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROBAST: Prediction model Risk Of Bias ASsessment Tool
QUIPS: Quality In Prognosis Studies

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30/08/2026

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