DOI: 10.53469/jcmp.2025.07(11).16

Research Progress on Stability of Distal Radius Fractures

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Abstract: ***Distal radius fractures are one of the most common fractures, and the core of treatment decisions lies in accurate judgment of fracture stability. However, the definition and evaluation criteria for stability have not yet been unified. This article systematically reviews the relevant literature on the stability of distal radius fractures. Although the classic Lafontaine criterion is widely used, its predictive power is controversial; the revised model developed by Dissanewate et al. emphasizes quantitative indicators such as age stratification and radius shortening, showing better discriminatory ability. At the same time, various studies have proposed more different prediction methods. Although existing classification systems and prediction models provide important basis for clinical judgment, stability assessment of distal radius fractures is a multi-dimensional process, and further high-quality research is needed to verify and optimize existing standards.***

Keywords: Distal radius fracture, Fracture stability, Predictive model.

1. Introduction

Distal radius fractures are one of the most common orthopedic injuries, accounting for 20% of all fractures treated in emergency departments and orthopedic clinics [1,2]. Its epidemiology shows a typical bimodal distribution: the first peak occurs among adolescents and young men who are keen on high-risk sports, usually high-energy injuries; the second peak occurs among postmenopausal women with osteoporosis, mostly caused by low-energy falls [3]. As the global population ages, the incidence of elderly distal radius fractures continues to rise, posing a significant challenge to social medical resources [4].

The “stability” of fractures is the cornerstone of the distal radius fracture treatment system. For stable fractures, traditional closed reduction combined with plaster or small splint external fixation can usually achieve satisfactory results [5-6]. However, for unstable fractures, the rate of redisplacement after non-surgical treatment can be as high as more than 60%, ultimately leading to malunion and wrist joint dysfunction [7]. Therefore, accurately identifying unstable fractures in the early stages of treatment and taking active intervention measures (such as open reduction and internal fixation) are crucial to improving the long-term prognosis of patients. Unfortunately, despite decades of research, the academic community has not yet reached a complete consensus on the definition and judgment criteria for the stability of distal radius fractures, and clinical decision-making still relies largely on the personal experience of the physician [8]. This review aims to systematically sort out the existing imaging evaluation system, integrate the latest research evidence, and provide a reference for establishing a standardized and quantitative stability assessment process.

2. Definition of Distal Radius Fracture Stability

In the clinical context, the stability of distal radius fractures is difficult to define, and the stability of early distal radius fractures is believed to be the ability of the fracture end to resist re-displacement and maintain acceptable alignment (i.e. functional reduction) during bone healing after initial closed reduction and external fixation is applied [9]. Unstable fractures are fractures that present a high risk of secondary displacement when treated conservatively. No other more rigorous definition has been proposed yet. The pathophysiological basis of its instability mainly stems from the following aspects: 1) Loss of bony structure: Severe fragmentation of the metaphysis, especially the joint destruction of the volar and dorsal cortex, resulting in the loss of the support points for internal fixation and difficulty in restoring. Maintain [10]. 2) Ligament traction: The change in the tension of the wrist ligament caused by fracture will have a continuous traction effect on the fracture fragment, especially during wrist joint activities [11]. 3) Osteoporosis: The patient’s bone quality directly affects the holding power of internal fixation and the resistance of external fixation to re-displacement. In osteoporotic bones, collapse and displacement are more likely to occur after reduction [12].

3. Classification System for Distal Radius Fractures

An effective classification system should indicate fracture stability, guide treatment, and predict prognosis. Currently commonly used classification systems include:

Classification named after people’s names [13]: Fractures are often divided into: colles fracture, smith fracture, barton fracture, chauffeur fracture and cotton fracture. The first three types are currently the most commonly used, describing extension, flexion and articular surface types, avulsion fractures of the styloid process of the radius, and fractures of the central articular surface of the distal radius. Various naming methods are classic, but they are too simple to fully assess the complexity and stability of fractures.

AO/ASIF classification: Fractures are divided into three categories: extra-articular (type A), partially intra-articular (type B), and completely intra-articular (type C). It is generally believed that type B and type C fractures, especially types C2 and C3, have a significant increase in instability due to the involvement and fragmentation of their articular surfaces [14].

Frykman classification: This classification takes into account the involvement of the radiocarpal joint and the distal radioulnar joint and the presence of ulnar styloid process fractures. The higher the classification, the more complex the injury is, but the direct correlation with modern treatment decisions is weaker [15].

Although there are many classification systems, most have limited direct links to fracture stability, and inter-observer agreement is often not high [16]. Therefore, clinicians prefer to rely on specific, quantifiable imaging parameters to assess stability.

4. Instability Factors for Distal Radius Fractures

4.1 Patient Related Factors

Influence mechanism of old age: This is one of the most powerful predictors. With age, especially in women after menopause, osteoporosis intensifies, resulting in sparse trabecular structures and decreased bone density in cancellous bone of the distal radius. This bone mass cannot provide sufficient mechanical support for the reduced fracture fragment and is prone to collapse and displacement even under plaster external fixation [17]. Multiple studies have used age > 60 years as a key threshold. Lafontaine et al. listed it as one of the top five instability criteria [18]. Mackenney's large prospective study (n=1, 595) confirmed that age was an independent predictor [19]. Early research by Abbaszadegan et al. also pointed out that age is one of the most important predictors of secondary displacement of Corre's fractures [20].

Although osteoporosis is highly related to advanced age, it is an independent pathological state. Even younger patients have an increased risk of fracture instability if they have secondary osteoporosis (such as long-term glucocorticoid use, endocrine diseases). Poor bone quality directly leads to the weakening of the holding power of the internal fixation. The study by Clayton et al. clearly showed that there was a significant correlation between the severity of distal radius fractures and the decrease in bone mineral density in patients [21].

Functional needs and compliance, the actual risk of instability is also higher for young patients with high functional needs or patients who are unable to cooperate with restricted activities (e.g., due to cognitive impairment) [39].

4.2 Fracture-related Factors (Imaging Factors)

These imaging factors were obtained primarily by evaluation of initial radiographs (posteroanterior and lateral). Radial shortening (positive ulnar variation): Loss of length of the radius relative to the ulna. Shortening > 3-5mm indicates severe damage to the supporting structure of the radial column. Mackenney's study found that initial foreshortening compared to the healthy side is an extremely strong predictive signal [19]. Cooney et al. identified radius shortening > 10mm as a sign of instability as early as 1979 [22]. Dorsal angulation (dorsal inclination): Normal distal radius has a palmar inclination of approximately 10-12°. When the fracture results in dorsal angulation of > 20°, it is easy to return to a deformed state after reduction. It is included in the standards of Lafontaine [18] and Cooney [22]. A study by Hove et al. confirmed that initial dorsal angulation is an important predictor of secondary displacement [23]. Loss of radial deviation angle: Normal radial deviation angle is approximately 22-23°. Its significant reduction means that the supporting effect of the radial styloid process is lost. Fractured dorsal metaphysis: This is one of the most critical factors. Dorsal cortical fragments failed to provide support for the reduced articular surface, causing it to settle dorsally.

The Lafontaine criterion [18], Cooney criterion [22], and Poigenfürst criterion [24] all emphasize the importance of dorsal comminution. Mackenney's research listed "the presence of any shredding" as one of the top three predictors [19]. Volar metaphysis comminution: Although rare, once present, it also means loss of supporting structure, common in volar displaced (Smith) fractures. Intra-joint involvement, if the articular surface step is greater than 2mm: the separation and step of the fracture fragments in the joint are not only a sign of instability, but also the main risk of traumatic arthritis in the long term.

The classic study by Knirk and Jupiter clearly states that poor reduction of the articular surface (step > 2mm) is significantly associated with the incidence of post-traumatic arthritis [25]. Complex intra-articular fractures (AOC type): In particular, AOC type 2 and C3 fractures are recognized as highly unstable types [26]. Ulnar Fracture: A fracture of the base of the ulna styloid process strongly suggests that the stability of the lower radioulnar joint (DRUJ) has been compromised, especially the deep avulsion of the triangular fibrocartilage complex (TFCC). Poigenfürst was the first to emphasize the importance of fractures of the base of the styloid process of the ulna leading to avulsion of the radioulnar ligament and instability [24]. Several subsequent biomechanical and clinical studies also support this view [27].

4.4 Functional Predictors

Irreversibility, the inability to achieve acceptable anatomical alignment through closed techniques, is itself a testimony to soft tissue incarceration or severe instability of fracture fragments. Nesbitt's systematic review listed "non-resettability" as the seventh most common definition [28]. The study by Wichlas et al. specifically explored the relationship between irresettability and instability [29]. Early redisplacement after reduction, followed by follow-up X-rays within one or two weeks after the initial satisfactory reduction, showing significant displacement, is the most direct evidence of fracture instability. Evidence supports: McQueen et al. used this type of "redisplaced" fracture as the gold standard for instability in several studies and used it as a basis to compare the advantages and disadvantages of different treatment modalities [30].

5. Prediction Model for Stability of Previous Distal Radius Fractures

5.1 Lafontaine Prediction Model

Core variables: The model proposes that if 3 or more of the following 5 factors are present, fracture instability is predicted: 1) Initial dorsal angulation > 20°, 2. dorsal metaphysis comminution, 3) Intraradial carpal fracture, 4) Combined ulnar fracture, 5) Age > 60 years old. This model stems from a retrospective cohort study [18]. Its advantage is that it is simple and easy to remember, combines patient factors (age) and fracture morphology factors, and is widely cited in clinical practice. Validation and Limitations: Subsequent validation studies have shown differences in predictive efficacy. Nesbitt et al. found that among the five factors in the model, age > 60 is the most consistent independent predictor, while the weights of other factors may vary by population [28].

5.2 Lafontaine Improved Prediction Model

Dissanewate et al. conducted an external verification of the Lafontaine standard in 2025. The study included 274 patients who underwent closed reduction and plaster fixation. The results showed that the AUROC of Lafontaine criterion was only 0.65 (95% CI 0.57 - 0.74), which did not meet the acceptable criterion of discrimination (AUROC ≥ 0.7) [31]. Further analysis found that among the original five predictors, only “age>60 years old” and “combined ulnar fracture” were still predictive value in multivariate analysis. Although “dorsal comminuted fracture” was associated with instability, its inter-evaluator reliability was poor (κ=0.48), which limited its clinical application. Based on multivariate logistic regression analysis, Dissanewate et al. proposed revised prediction criteria, including: age 56-74 years (1 point), age>74 years (2 points), combined ulnar fracture (1 point), and initial radius shortening>3mm (1 point). A total score of ≥2 indicates unstable fracture. The AUROC of this model is 0.74 (95% CI 0.66 - 0.82), which is better than the original Lafontaine criterion, and the increasing risk of remigration is more consistent across different score levels, showing better clinical applicability.

5.3 Mackenney Prediction Model

Core variables: Based on a large prospective study (n=1,595), this model established the three strongest independent predictors [19]. Age (as a continuous variable, the risk increases with age), the presence of any type of bone fragmentation, ulnar variation on the injured side compared to the healthy side (i.e., shortening of the radius). The study was prospectively designed, with a large sample size and a high level of evidence. The model is concise and clear, containing only three variables, making it easy for rapid clinical application. Based on this, the researchers developed a Nomogram that quantifies the risk of remigration for specific patients. This model confirms that axial shortening of the radius (ulnar variation) is an extremely important indicator of instability, sometimes even more important than simple dorsal angulation.

5.4 Other Scoring Systems and Standards

Cooney Criteria [22]: As an early comprehensive description, it defines “instability” as the presence of one or more of the following conditions: severe bone fragmentation, intra-articular fracture fragments, and severe initial displacement (defined as dorsal angulation>20° or radius shortening>10mm). This provides the basis for subsequent model construction.

Three-Point Index [32]: This scoring system is designed to predict redisplacement of extra-articular distal radius fractures. It scores by measuring cortical alignment at three specific points on a lateral X-ray. First point: Dorsal cortex location: Measure the percentage of alignment of the dorsal cortex approximately 1 cm proximal to the radiocarpal joint surface. Second point: Volar cortex location: Measure the percentage of alignment of the volar cortex approximately 1 cm proximal to the radiocarpal joint surface. Point 3: Radial styloid cortical position: Measure the percentage of radial cortical alignment approximately 1 cm proximal to the radial styloid apex (cortical alignment in this area can be assessed on lateral radiographs). 0 points: complete cortical alignment (contact area > 95%), 1 point: incomplete cortical alignment (contact area < 95%), 2 points: complete cortical absence (contact area 0%). The higher the score, the smaller the cortical contact area, the worse the stability, and the higher the risk of remigration.

Jiang Baoguo criteria [33]: Combined with clinical practice in China, it integrates bone quality (cortical comminution>50%, osteoporosis), displacement (dorsal inclination>15°, shortening>4mm) and combined injuries (ulnar styloid process base fracture, lower ulnar radial joint instability). Chen Xing’s prediction of the stability of various distal radius fractures believes that Jiang Baoguo’s criterion (more comprehensive, including soft tissue and bone considerations) has the highest consistency rate with the final functional reduction results, and believes that an ideal stability criterion should take into account the integrity of the articular surface, alignment in the sagittal and coronal planes, and the patient’s bone conditions. [34]

Batra et al. [35] reported that ERLF (effective radiolunate alignment) angles>25° indicate malalignment of the carp-metacarpal and are highly correlated with early and late fracture re-displacement. Rhee and Kim introduced MCR (themetaphyseal collapse ratio) as an indicator of dorsal phalangeal fragmentation and found that it significantly predicted instability and had good inter-rater reliability based on two raters [36]. LaMartina et al. [37] concluded that volar hooks are a strong predictor of final volar angulation and loss of volar angulation, while Mathews et al. [38] found that poor reduction of the volar cortex was associated with re-displacement and malunion at week 6 for conservative quality of distal radius fractures.

6. Conclusion

Evaluation of the stability of distal radius fractures is a core step in determining treatment options and influencing patient prognosis. Through a systematic review, this paper shows that fracture stability is not determined by a single factor, but is the result of multi-dimensional and multivariate interactions such as the patient’s own factors (such as advanced age, osteoporosis), fracture morphological characteristics (such as radius shortening, dorsal angulation, metaphysis fragmentation, and intra-joint involvement), and functional manifestations (such as irreducibility, early redisplacement).

Although the classic predictive model represented by the Lafontaine criterion provides a preliminary framework for clinical judgment, its predictive power has limitations and inter-observer differences. Mackenney's model established three independent predictors of age, bone fragmentation, and radius shortening through a large sample of prospective studies, with a higher level of evidence. Dissanewate et al. (2025) revised the Lafontaine criterion, which further improved the discriminative ability and clinical applicability of the model by introducing age stratification and quantified radius shortening indicators, represents an important progress in this field. At the same time, comprehensive evaluation systems such as Jiang Baoguo's standard combined with local clinical practice, as well as the exploration of new quantitative parameters such as MCR and volar hook, have provided useful supplements for comprehensive assessment of stability.

To sum up, there is no recognized and accurate model to assess the stability of distal radius fractures. Future research on the stability of distal radius fractures should be committed to integrating diversified predictive indicators and developing and widely verifying more accurate quantitative scoring tools. In the future, we will further promote the standardization and objectivity of the evaluation process to achieve individualized and precise treatment, effectively reduce the risk of re-displacement and malunion, and ultimately improve the function of the wrist joint in patients with distal radius fractures.

Acknowledgements

Joint project of Shapingba District Science and Technology Bureau and Health Commission of Chongqing City, project number: 2024 SQKWLHM036.

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