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Predicting the Outcome of Distal Radius Fractures

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The anatomic results of fracture treatment have no meaning unless they are considered in light of the functional outcome [1]. There are myriad factors affecting the clinical result following a distal radius fracture. It is useful to identify those factors that have some predictive value with regard to fracture instability, patient satisfaction, and hand function. These variables are discussed in light of the specific outcome of interest.

Predictors of fracture instability

A fracture of the distal radius is considered to be unstable if it is unable to resist displacement once it has been reduced anatomically. There are difficulties in predicting fracture instability reliably based on the radiographs alone. MacKenney and Adolphson et al [2] have devised scoring systems to calculate the probability of fracture instability on the basis of the initial presentation and the injury films. In a prospective study of 80 patients, both scoring systems were found to underestimate the degree of fracture instability and to have a poor correlation with the predicted and the actual instability [3].

The standard radiographic parameters of the distal radius include a radial inclination of 23° (range, 13°–30°), a radial length of 12 mm (range, 8–18 mm), and an average volar tilt of 12° (range, 1°–21°) [4–7]. Lafontaine et al identified several risk factors associated with secondary fracture displacement despite a satisfactory initial reduction. These included the presence of dorsal tilt $>20°$, comminution, intra-articular involvement, an associated fracture of the ulna, and age greater than 60 years. If three or more of these factors were present there was a high likelihood of fracture collapse [8]. Several studies have determined that the severity of the initial radial shortening alone seems to be a reliable indicator of instability [9–11].

In patients older than 60 years of age, Leone et al found that the degree of radial shortening and volar tilt and the amount of dorsal comminution were predictive of early or late failure. An unexpected finding was that in patients older than 65 years of age, one third of the initially undisplaced fractures subsequently collapsed [12]. Nesbitt et al determined that age was the only statistically significant predictor of secondary displacement. After obtaining an acceptable initial closed reduction, those patients who were more than 60 years of age had four times the risk for failure within the initial 4 weeks as compared with younger patients. The risk for displacement increased with each subsequent decade [13].

It is apparent that late fracture displacement is common in elderly patients, which may be related to their lower bone density. Thought should be given to adjuvant percutaneous or external fixation in the healthy, active elderly patient if there is a loss of fracture position in the first month. Greater force is necessary to fracture the radius in younger patients because of their higher bone density, which can result in more comminution and a higher risk for subsequent fracture collapse [14]. Supplemental internal or external fixation is indicated in younger patients for fractures with >2 mm of radial shortening and $>15°$ of dorsal tilt following a closed reduction, especially if there is comminution of two or more cortices [15,16].

Predictors of osteoarthritis

Knirk and Jupiter retrospectively reviewed 43 intra-articular fractures in 40 young adults (mean age, 27.6 years) with a mean follow-up of 6.7

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years. Thirty-eight fractures were treated with cast or pins and plaster. Accurate reduction of the articular surface was the most critical factor in achieving a successful result. Radiographic evidence of arthritis developed in 100% of the fractures whose articular incongruity was 2 mm or more, in contrast to only 11% of the fractures that healed with a congruous joint [17]. Altissimi et al analyzed the outcomes of 59 patients with comminuted intra-articular fractures of the distal radius who had received conservative treatment, at an average follow-up of 3.5 years. Thirty-one percent of the patients with greater than 2 mm of residual articular malalignment were noted to have degenerative arthritis [18]. Catalano et al studied 21 patients younger than the age of 45 years who had undergone internal fixation of displaced intra-articular fractures. At an average of 7.1 years, osteoarthrosis of the radiocarpal joint was radiographically apparent in 16 wrists (76%). A strong association was found between the development of osteoarthrosis of the radiocarpal joint and residual displacement of articular fragments at the time of bony union ($P < 0.01$) [19]. Fernandez et al observed that intra-articular incongruence of 1 mm or greater resulted in the development of arthrosis [20].

The predictive value of these studies is that articular incongruity following a distal radius fracture is the most significant factor in the development of radiocarpal osteoarthritis (OA). Articular displacement that is identified on the initial injury films thus warrants a more aggressive surgical approach.

Predictors of residual disability

Radiographic predictors

Many studies have supported the link between late deformity and functional outcome following a distal radius fracture since the landmark article by Garland and Werley [21]. Fujii et al determined that fractures that had healed with 6 mm or more of radial shortening were likely to have a poor functional outcome [22]. In a study of 92 patients older than the age of 55 years, Aro and Koivunen found that even minor axial shortening of the radius with a Colles fracture carried an increased risk for permanent disability. The functional end result was unsatisfactory in 4% of the patients with an acceptable anatomic result, in 25% of the patients with radial shortening of 3–5 mm, and in 31% of patients with shortening of more than 5 mm [23]. This finding does not seem to change over time. Eighty-five patients with displaced Colles fractures were reviewed 10 years after the injury. Initial and 10-year radial shortening and early finger stiffness significantly correlated with final outcome. Dorsal angulation influenced early but not 10-year function [24].

Combined deformities are also of significance. Fractures healing with more than 2 mm of axial compression and $>15^{\circ}$ of dorsal angulation have compromised outcomes [25,26].

Intracarpal lesions

Arthroscopic evaluation of extra- and intra-articular distal radius fractures has revealed that triangular fibrocartilage (TFC) and interosseous ligament tears are much more common than suspected previously [27,28]. These chondral and ligamentous lesions may explain poor outcomes after seemingly well healed fractures in young adults and [29]. Although preoperative radiographs had no predictive value for interosseous ligament injury, those patients with TFC tears had greater radial shortening and dorsal angulation [27].

Post-traumatic osteoarthritis

Experimental work on displaced intra-articular distal radius fractures has measured significant changes in mean contact stresses with step-offs as small as 1 mm [30]. Wrist pain has related significantly to the size of the intra-articular step [31]. These findings have prompted some investigators to recommend surgical treatment for residual articular incongruity of ≥ 1 mm [15,32].

Ulnar wrist pain

A study of 109 Colles fractures treated with closed reduction and casting determined that the most important factor for predicting ulnar wrist pain was incongruity of the distal radioulnar joint (DRUJ) secondary to residual dorsal angulation of the radius [33]. Others have found that an increase in the ulnar variance was the most important radiologic parameter affecting outcome [34]. Ulnocarpal impingement and DRUJ incongruency are related to the amount of radial shortening and are a common cause of ulnar-sided wrist pain [35]. In young patients, DRUJ instability is another cause of residual pain following a distal radius fracture. Lindau et al, however, could not correlate this instability with any specific radiographic parameter [36].

Grip strength loss

More than 10° of dorsal tilt leads to a dorsal carpal shift with compressive forces, which causes pain and insecurity with gripping. This has been associated with increased difficulty with everyday activities and work [37]. Dorsal angulation of $>20°$ and reduction of the radial angle to less than 10° can result in a reduction in grip strength [38].

Others have found that grip strength correlated negatively with the degree of osteoarthrosis [39].

Work-related injury

Injury compensation is a predictive factor with regard to patient-reported pain and disability. In a prospective study of 120 patients sustaining a distal radius fracture, the most influential predictor of pain and disability at 6 months was injury compensation. Wrist impairment was correlated moderately with patient-reported pain and disability [40]. Fernandez et al found that patients with work-related injuries were more than four times less likely to return to work than those injured while away from work [20].

The message gleaned from these data is that aggressive efforts should be made to achieve a congruent joint reduction and to circumvent an excessive loss of radial length or abnormal tilt of the articular surface to prevent residual impairment and pain. Intracarpal pathology should be suspected in patients with persistent wrist pain despite acceptable bony alignment. Patients with work-related injuries are apt to have poorer outcomes regardless of the anatomic result.

Predictors of loss of wrist motion

Experimentally, dorsal tilt of up to 30° and radial translation of up to 10 mm leads to no significant restriction in forearm pronation or supination. Radial shortening of 10 mm, however, reduces forearm pronation by 47% and supination by 29%. Five mm of ulnar translation deformity results in a mean 23% loss of pronation [41]. Clinical experience has shown that radial shortening of 2 mm or greater and dorsal angulation of more than 15° was directly related to diminished range of motion [25]. Hove et al found that the total movement in all directions was diminished with an ulna plus deformity and that pronation and supination were related to the initial radial length and dorsal angulation [39].

Comminution and intra-articular involvement also predispose toward a loss of movement [38]. In a study of 169 distal radius fractures in adults younger than age 50, fracture union with a step in the radiocarpal articular surface was associated with loss of wrist mobility and difficulty with fine dexterous tasks [37].

The predictive value of this evidence is that if a loss of motion is caused by bony malalignment, prolonged therapy is of no benefit.

Predictors of patient satisfaction

Wrist pain/grip strength

Fifty-three items were evaluated by a group of 55 patients recovering from a fracture of the distal radius, which established the prevalence, mean severity score, and overall severity score (or impact) of each item as it relates to physical function and social/emotional impact. The amount of residual wrist pain influenced patient satisfaction more than motion did. Hand dominance was also a significant factor [42].

Trumble et al devised a combined injury score rating system that included grip strength, range of motion, and pain relief to grade the results following internal fixation of displaced intra-articular distal radius fractures. In this retrospective study 43 patients were evaluated at a mean of 38 months. Patient satisfaction seemed to correlate best with pain relief and grip strength rather than the postoperative loss of palmar tilt or radial tilt. Preoperative step-off and gap and radial shortening were equated with worse outcomes [16].

In other clinical trials, Fujii et al noted that the grip power was the most significant factor related to subjective evaluation [22]. A prospective study of 31 patients recovering from unstable fractures of the distal radius investigated the association between objective variables and the level of post-traumatic disability of the wrist as measured by the patient-rated wrist evaluation (PRWE) score. Grip strength was shown to be a significant predictor of the PRWE score and seemed to be a sensitive indicator of return of function of the wrist [43].

Osteoporosis

A study of the bone mineral densitometry in women older than age 40 years who sustained a distal radius fracture demonstrated that the

clinical results correlated better with bone mineral density than with the radiologic parameters [44].

The gist of these observations is that a loss of bony alignment does not always equate with disability. Although surgeons continue to strive for perfection, some degree of malalignment seems to be well tolerated. Patient satisfaction often hinges on pain relief and return of grip strength rather than anatomic restoration. This was affirmed by one prospective study of 85 patients who were randomized to bridging external fixation or plaster immobilization for treatment of a Colles type distal radial fracture. Despite a high level of radiographic malunion (50%), overall function, range of movement, and activities of daily living were not limited [45]. It does seem that involvement of the dominant hand and osteopenia may influence the end result.

Factors not invariably predictive of outcome

Acceptable reduction

The relationship between form and function is not invariable. MacDermid et al found that an acceptable radiographic reduction of dorsal/volar tilt criteria was not associated with better self-reported functional outcomes or increased satisfaction at 6 months in elderly patients with conservatively treated distal radius fractures [46].

In the evaluation of the outcomes using the Short form 36, a study of 50 patients with a mean age of 49.6 years found no correlation with residual radial height, radial tilt, or palmar tilt following internal or external fixation of distal radius fractures. Intra-articular incongruence of 1 mm or greater, however, did correlate with a lower score [20].

Malunion

Gliatis et al assessed the outcome of 169 fractures of the distal radius in adults younger than age 50 years at a mean follow-up of 4.9 years. No measure of intra- or extra-articular malunion influenced the severity or frequency of persistent wrist pain [37]. A retrospective study of Colles fractures in patients 60 years or older revealed an 82% incidence (11 patients) of good to excellent outcomes in undisplaced fractures as compared with a 68% incidence (25 patients) in re-displaced fractures [47].

Dayican et al analyzed the results of 108 patients older than 70 years of age with intra-articular distal radial fractures who would not consent to an operation. At a mean follow-up of 39.5 months, 88.9% were considered to have good and excellent functional results even though 25.9% of the patients had fair and poor anatomic scores [48].

Kelley et al studied 30 elderly patients with moderately displaced Colles' fractures (10°–30° of dorsal angulation and <5 mm of radial shortening) who were randomly assigned to manipulation under Bier block or plaster immobilization alone. There was no detectable difference between the groups in any of the outcome measures. Two thirds of the correction of dorsal angulation achieved by manipulation was lost by 5 weeks. They concluded that up to 30° of dorsal angulation and 5 mm of radial shortening may be accepted in selected elderly patients [49]. This finding was duplicated by Beumer and McQueen. In a series of 60 fractures with a mean patient age of 82 years (range, 65–93 years), 53/60 fractures healed in a malunited position. They found no correlation between fracture classification, initial displacement, and final radiographic outcome. On the basis of these observations they concluded that reduction of fractures of the distal radius is of minimal value in old and frail, dependent, or demented patient [50].

Osteoarthritis

The radiographic presence of OA does not always affect adversely the functional outcome [45]. In a series of 21 patients with surgically treated intra-articular fractures, osteoarthrosis of the radiocarpal joint was radiographically apparent in 16 (76%) of the wrists at an average follow-up of 7.1 years. The functional status, however, did not correlate with the magnitude of the residual step and gap displacement at the time of fracture healing. All patients had a good or excellent functional outcome irrespective of radiographic evidence of osteoarthrosis of the radiocarpal or the DRUJ [19].

Wrist motion

Forearm rotation and flexion and extension of the wrist were not significantly associated with the PRWE score [43]. Absolute wrist motion has been found subjectively to be less relevant than grip strengths and residual wrist pain [42].

One can see that wrist impairment is not always synonymous with a poor functional outcome.

Summary

There are myriad factors that affect patient satisfaction following a distal radius fracture, including anatomic alignment, age, motion, pain, and hand dominance to name a few. The seeming contradictions in the literature serve to illustrate that individual outcomes are not entirely predictable because of the different functional demands, expectations, and pain tolerance for each patient. Elderly populations may tolerate greater degrees of residual deformity because of a more sedentary lifestyle. Unrecognized intracarpal pathology may account for poor results despite acceptable radiographic alignment. Possessing a knowledge of the predictive factors that affect adversely the functional outcome, however, does allow the surgeon to manage complications proactively to maximize the potential for an acceptable end result.

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