

# Current Concepts in the Management of Distal Radius Fractures

## Současný stav v oblasti léčby zlomenin distálního radia

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### SUMMARY

The treatment of fractures at the distal end of the radius continues to challenge orthopaedic and upper extremity surgeons. As our understanding of the injury mechanism and local anatomy continues to improve, so too have our surgical techniques in helping patients regain functional use of the injured extremity. The purpose of this manuscript is to review the treatment methods available for distal radius fracture management.

### INTRODUCTION

Distal radius fractures represent one of the most common injuries treated by upper extremity surgeons (15, 16), accounting for 16% of all fractures treated in the emergency room in the United States and 75% of fractures of the forearm. The age distribution for injuries to the distal radius is typically bimodal with peaks in the 5–14 year age group and in elderly patients older than 60. Most distal radius fractures occur in elderly females with a male-to-female ratio of 1 to 4.

The treatment of fractures at the distal end of the radius has certainly evolved since Abraham Colles provided the first description to the English-speaking community in 1814 (8). In his initial report, Colles noted that these fractures tended to do well despite considerable deformity. This assertion was later supported by Cassebaum (4) in 1950. Finally in 1988, McQueen and Caspers (21) demonstrated a clear correlation between malunion of the distal radius and poor functional outcomes. Since then, we have witnessed a growing body of literature devoted exclusively to the treatment of the distal radius fracture.

This review will briefly discuss methods for appropriate evaluation of distal radius fractures, highlight salient characteristics of various classification systems, and explore current concepts in the treatment of these injuries.

### EVALUATION

Since 1898, radiographic analysis has formed the foundation for evaluation of distal radius injuries. An initial set of radiographs generally include standard anteroposterior, lateral, and oblique views of the affected wrist. Scaphoid views and full-length forearm views

may be obtained as needed. Guidelines for optimal positioning of the distal end of the radius have evolved such that most orthopaedic and hand surgeons strive for radial inclination greater than 15 degrees; radial tilt between 15 degrees of dorsal angulation to 20 degrees of volar angulation; radial length with less than 5 mm of shortening at the distal radioulnar joint; and less than 2 mm of intraarticular step-off between fracture fragments (13) (Table 1).

Tab. 1. Radiographic Criteria for Acceptable Healing of a Distal Radial Fracture

Radiographic Criterion	Acceptable Measurement
Radioulnar length	Radial shortening of < 5 mm at DRUJ compared with contralateral wrist
Radial inclination	Inclination on PA film ≥ 15 degrees
Radial tilt	Sagittal tilt on lateral projection between 15-degree dorsal tilt and 20-degree volar tilt
Articular incongruity	Incongruity of intra-articular fracture is ≤ 2 mm at radiocarpal joint

Standard radiographic views, however, may be inadequate to characterize complex distal radius fractures. While infrequently required, computed tomography may be particularly helpful in defining the fracture lines of complex articular injuries or in defining an injury to the distal radioulnar joint. Computed tomography may also be useful for suspected die-punch, volar rim, or scaphoid facet fractures. With improving technology, three-dimensional reconstructions can provide the surgeon detailed information for appropriate preoperative planning.

## CLASSIFICATION

Various classification systems have been proposed for fractures at the distal radius. Each distal radius fracture differs in the mechanism of injury, the energy of injury, the degree of articular involvement, and associated injuries. Among the early attempts to define the varying patterns of articular fractures of the distal radius were those of Castaing (5) in 1964 and Frykman (11) in 1967. Though the latter classification has been widely cited in the English language literature, it fails to give critical information about the extent and direction of articular fracture displacement. Melone (23) observed four basic components in the classification system which bears his name: the radial shaft, the radial styloid, the posteromedial portion of the lunate facet of the distal radius, and the palmar medial portion of the lunate facet.

The Fernandez classification system (10) is based on the mechanism of injury and may facilitate manual reduction of a distal radius fracture. Type I fractures are simple bending fractures of the metaphysis that are low energy, typically the result of a ground level fall. These include extraarticular Colles' or Smith's fractures. Type II fractures are shearing injuries that result from obliquely directed forces through part of the articular surface. These fractures are inherently unstable and typically require open reduction internal fixation. Type III fractures are compression injuries of the joint surface with impaction of the subchondral bone. Depending on the degree of energy there may be minimal or considerable displacement. Type IV injuries are fracture-dislocations and may be deceptively simple-appearing. A fracture through the radial styloid, for example, may propagate through the scapholunate ligament, resulting in an intercarpal dislocation. Type V fracture are high energy injuries associated with soft tissue loss and are also referred to as combined complex injuries. The outcome of these injuries is dictated as much by bony reconstruction as it is by the extent of soft tissue injury and reconstruction (Fig. 1).

## GOALS OF TREATMENT

How aggressively one pursues surgical reconstruction of distal radius fractures is dictated by the demands of the patient and the radiographic findings at the time of injury. Those patients with low demand activities may be best served with nonoperative techniques. High demand patients, however, may require surgical fixation to allow early range of motion and to prevent stiffness, which could be detrimental for certain activities.

The significance of articular incongruity is still debated in treating patients with distal radius fractures. Articular incongruity for intraarticular fractures may lead to decreased ability to remodel as the joint stepoff exceeds the thickness of the articular cartilage. Knirk and Jupiter (20) found that articular incongruity predisposed patients to the development of degenerative joint disease in the radiocarpal joint. In their study of young

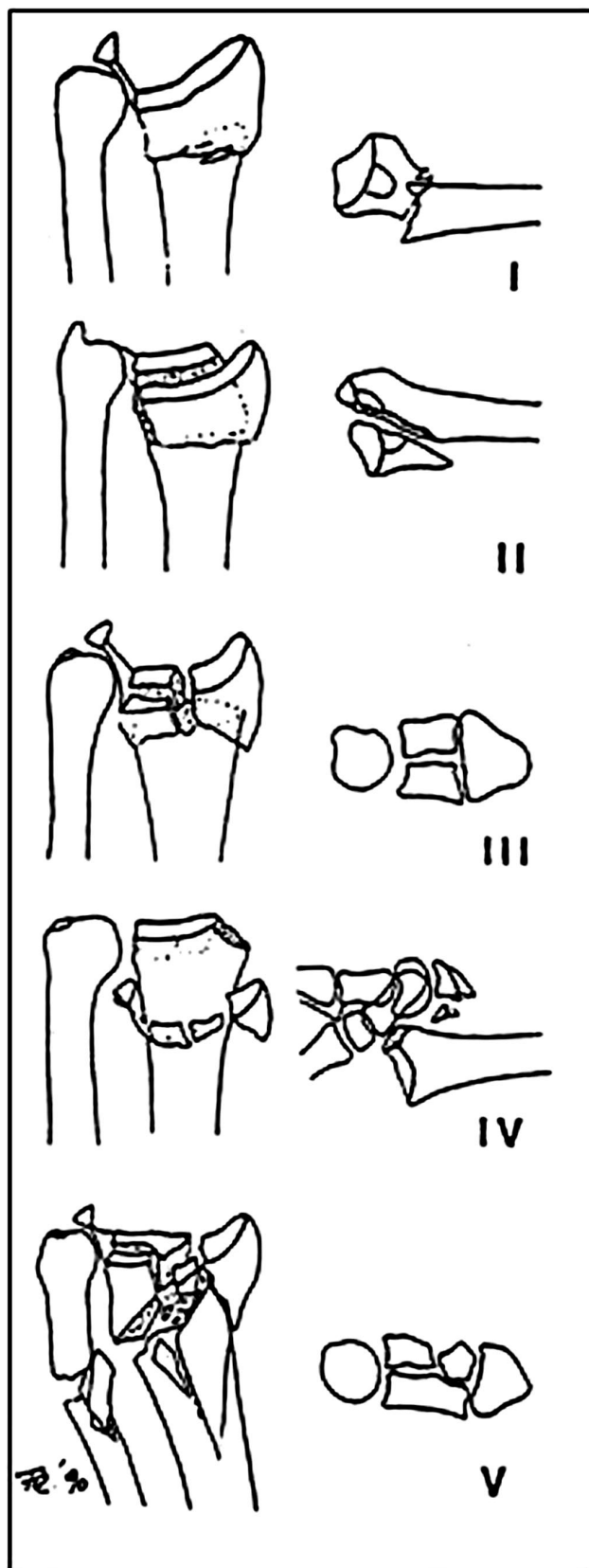


Fig. 1. The fracture classification of Diego Fernandez, M. D. based upon the mechanism of injury.



*Fig. 2. A well molded short arm cast applied for a stable distal radius fracture.*

patients, the absence of joint stepoff following treatment for an intraarticular distal radius fracture led to arthrosis in only 11% of patients. Stepoffs of 2 mm or greater, however, led to generative joint disease in 91% of patients.

Catalano (6) also found a strong association between intraarticular stepoff and degenerative joint disease but found that all patients presented with good or excellent outcomes an average of 7 years following surgery, regardless of the initial deformity. Goldfarb and Catalano (12) followed up this study by evaluating the same cohort of patients an average of 15 years after surgery. The authors found that patients continued to function at high levels, that strength and range of motion measurements were unchanged, and that the joint space was reduced an additional 67% in those patients with radiocarpal arthrosis. No correlation was noted between the presence or degree of arthrosis and upper extremity function as measured by DASH scores and the Gartland and Werley criteria. Clearly, intraarticular stepoff may not be as significant as previously believed.

## CAST IMMOBILIZATION

Multiple surgical treatments are available to upper extremity surgeons treating fractures of the distal radius. However, cast immobilization is an appropriate treatment for all non-displaced fractures and stable displaced fractures that have been reduced. It may also be appropriate for low demand patients who would not be able to tolerate surgery for medical reasons. Closed reduction of displaced fractures consist of longitudinal traction, palmar translation of the hand, pronation of the

hand relative to the forearm, and finally ulnar tilt. This reduction maneuver does not require wrist flexion.

Determining which fractures will heal uneventfully with cast immobilization may be difficult. An unstable distal radius fracture can be defined by several criteria, which include: comminution greater than 50% from dorsal to volar, angulation greater than 20 degrees of dorsal tilt, shortening greater than 10 mm, a shearing fracture pattern, and significant displacement with 100% loss of opposition (2). All unstable fracture patterns require surgical intervention.

Cast treatment typically consists of immobilization in a sugar-tong splint for three weeks immediately following closed reduction, which is then converted to a short arm cast for an additional three weeks. Patients are usually given a removable splint for a final three weeks and instructed to perform active assist range of motion exercises to regain flexibility. Early in the treatment course, radiographs should be obtained weekly to ensure fracture stability. The palmar crease should be free to allow full motion about the metacarpophalangeal joints (Fig. 2).

## PERCUTANEOUS PIN FIXATION

Because unstable distal radius fractures have a tendency to redisplace in plaster, percutaneous pinning is a relatively simple and effective method of fixation that is recommended for reducible extraarticular fractures, simple intraarticular fractures that are nondisplaced, and in patients with good bone quality.

Multiple different techniques have been described for pinning distal radius fractures. These include pins pla-



Fig. 3a-d. Percutaneous pin fixation of an unstable distal radius fracture: 3a. The xrays of the initial fracture. 3b. Two percutaneous pins through the radial styloid. 3c. Fracture healing in an anatomic position. 3d. Functional result.

ced through the radial styloid, two or three crossed pins across the fracture site, or intrafocal pinning within the fracture site. Some techniques also incorporate transfixation wires across the distal radioulnar joint for added stability. The actual technique used is probably not significant as long as the wires confer sufficient fixation to the fractured radius.

Kapandji (18) popularized the technique of double intrafocal pinning to both reduce and maintain distal radius fractures. This procedure is probably best reserved for noncomminuted extraarticular injuries. Kapandji's technique first requires a Kirschner wire introduced into the fracture site in a radial-to-ulnar direction. When the wire reaches the ulnar cortex, the wire is used to elevate the radial fragment and recreate the radial inclination. This wire is then driven through the ulnar cortex for stability. A second wire is introduced 90 degrees to the first in a similar manner to restore volar tilt. Generous skin incisions must be made about the pin sites to prevent skin tethering. Care must also be taken to avoid injury to the cutaneous nerves (Fig. 3a-d).

## EXTERNAL FIXATION

External fixators are typically used as an adjunct to other forms of fixation, particularly for the treatment of highly unstable or comminuted injuries. External fixators provide ligamentotaxis that can help to maintain fracture reduction, thereby preventing collapse. In addition, they function by neutralizing compressive, torsional, and bending forces across the fracture site. Occasionally, external fixators will be used for definitive reduction of fractures, but more often it will be used in conjunction with other forms of fixation.

Several biomechanical studies support the use of augmented external fixation with supplemental Kirschner wires. Wolfe (33) et al. performed a cadaveric study comparing osteotomized distal radii stabilized with an external fixator alone or with various supplemental Kirschner wire configurations. Fracture transfixation wires placed into the distal fragment and secured to the external fixator were superior to external fixation alone in reducing fracture motion. A single wire was





a|b  
|c

*Fig. 4a-c. An unstable intraarticular fracture treated with a nonbridging external fixation:*

*a. The preoperative x-ray; b. The non bridging fixation with an anatomic reduction; c. Follow-up healing with excellent position.*

enough to gain appreciable stability, and additional wires did not improve stability further.

Despite its usefulness, the rate of complications with external fixation is high. Complications include stiffness, pin tract infections, pin loosening, radial sensory nerve injury, and reflex sympathetic dystrophy. These complications may be avoided to some degree by avoiding carpal overdistracted, excessive wrist flexion, and prolonged fixator treatment (Fig. 4a-c, Fig. 5a-f).

#### ARTHROSCOPICALLY ASSISTED FIXATION

Wrist arthroscopy is a technique that provides a minimally invasive way of monitoring closed reduction of distal radius fractures with percutaneous pin fixation. Obviously, it allows assessment of the articular joint surface as well as the diagnosis of interosseous carpal ligament injury or triangular fibrocartilage complex injury. Finally, it facilitates the excision of osteochondral flaps and loose bodies as needed. Disadvantages of arthroscopically-assisted fixation include the steep learning curve associated with any arthroscopy procedure. To date, there are few studies that demonstrate improved functional outcomes with the use of arthroscopy.

To perform wrist arthroscopy, a small joint (2.7 mm) arthroscope may be introduced through the 3-4 portal. Instrumentation can be introduced through the 4-5 or 6-R portals. Wrist arthroscopy with fixation is general-

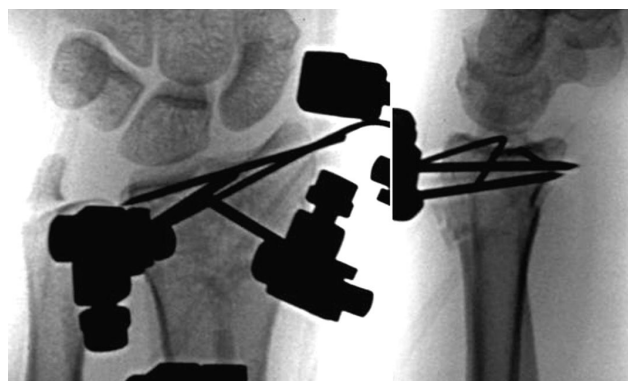


Fig. 5a

*Fig. 5a-f. A complex intrarticular fracture in a dentist treated with K-wires and a bridging external fixation: a. The original fracture; b. The CT scan; c. The fracture fixation; d. The dentist at work with his external fixation in place; e. X-rays of the healed fracture; f. Functional follow-up.*

Pokračování ►



Fig. 5b ◀▶

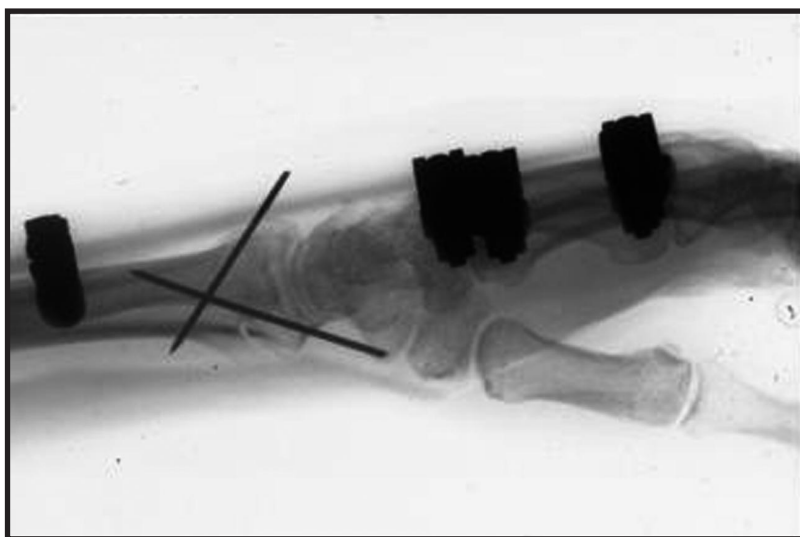


Fig. 5c ◀▶

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ly best achieved about four to seven days from the time of injury. Surgery performed too soon after injury may face difficulties with fracture hematoma impeding articular visualization. Likewise, fractures treated after one week from the time of injury may be difficult to manipulate with percutaneous wires. Fracture fragments are

typically elevated using Kirschner wires as joysticks. Fractures can then be pinned transversely beneath subchondral bone (Fig. 6a-b).

Doi et al. (9) analyzed the usefulness of arthroscopically assisted reduction of intraarticular fractures of the distal radius by comparing the results of that procedure with those of conventional open reduction and internal fixation. The authors performed a randomized prospective study, treating 34 patients with arthroscopically guided reduction and pinning and 48 with conventional open reduction internal fixation. The authors found with 30 month average follow-up that patients with arthros-



Fig. 5d ◀▶



Fig. 5f ▼

Fig. 5e ▶







a|b

Fig. 6 a-b. Arthroscopic assisted fixation: a. A displaced intraarticular fracture; b. Arthroscopic view of the articular fracture.

copically guided reduction had good or excellent results 82% of the time using the Gartland and Werley criteria, better ROM and grip strength, and an improved radiographic appearance compared to the open reduction cohort. On the basis of this study, Doi et al. concluded that arthroscopically assisted fixation of distal radius fractures is an effective technique in patients less than 70 years of age with intraarticular injuries.

#### OPEN REDUCTION INTERNAL FIXATION: DORSAL AND VOLAR

Open reduction internal fixation has obvious advantages over the other methods discussed so far. It allows direct restoration of anatomy, stable internal fixation, a decreased period of immobilization, and an earlier return of wrist function. There are a number of different indications for open reduction internal fixation, and these include: unstable articular fractures (such as a volar Barton's injury), impacted articular fractures, radiocarpal fracture-dislocations, complex fractures requiring direct visualization of the fracture fragments, and failed closed reductions.

Historically, distal radius fractures were treated nonoperatively until 1929, when techniques utilizing pins and plaster were introduced. External skeletal fixation evolved in 1944 and remained popular even after the AO group designed plates specifically for the treatment of distal radius fractures in the 1970s. In 1994, Agee introduced the Wrist Jack (Hand Biomechanics Lab Inc, Sacramento, CA), which utilized adjustable gears for multiplanar ligamentotaxis, but by this time open reduction internal fixation was becoming more popular, particularly when it was noted that precise reductions of the articular surface led to better outcomes (14).

The approach is generally dictated by the location of major fracture fragments and the direction of displacement. However, orthopaedic and upper extremity surgeons continue to move away from dorsal plating where complications can include extensor tendon rupture and hardware irritation. Volar plating is generally well-tolerated. Fixation of dorsally angulated and comminuted fractures is also possible with newer fixed angle devices.

Although overall satisfactory outcomes have been reported with dorsal plating systems, disadvantages of dorsal plates include the need for mobilization of extensor tendons to achieve proper plate placement, possible tendon irritation or rupture, and the possibility of additional surgery to remove the symptomatic dorsal plate, some reporting up to 30% (1, 3, 19, 27). Tendon rupture has been reported as early as 8 weeks and as late as 7 months after surgery. To prevent tendon injury, some recommend that a portion of the extensor retinaculum be interposed between the plate and the tendon sheaths, or that dorsal plates be removed routinely (7).

The advantages of a volar exposure and plating include the following: (1) Dorsally displaced fractures are simpler to reduce because the volar cortex is usually disrupted by a simple transverse line; (2) anatomic reduction of the volar cortex facilitates restoration of radial length, radial inclination, and volar tilt; (3) the avoidance of dissection dorsally helps to preserve the vascular supply to the dorsal fragments; (4) because the implant is separated from the flexor tendons by the pronator quadratus, the incidence of flexor tendon complications is lessened (17, 22); and (5) when stabilized with a fixed angle internal fixation device, shortening and secondary displacement of articular fragments is improved, and the need for bone grafting is reduced (Fig. 7a-b).



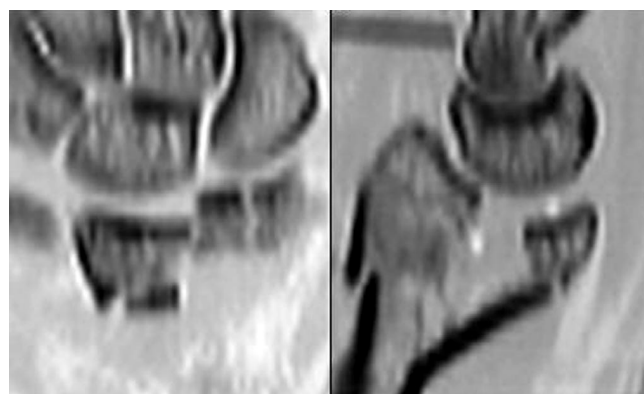


Fig. 7a ◀▶



Fig. 7b ◀▶

*Fig 7a-b. A complex intraarticular volar displaced fracture; a. The xray and CT views of the fracture; b. Volar plate fixation with angular stable Synthes plate with functional result*

With the recent popularity of volar plating for treatment of distal radius fractures, we have witnessed a multitude of medical devices introduced into the market. Not surprisingly, these devices exhibit many similar characteristics. Volar plates are typically T-shaped to allow multiple fixation points in the distal fracture fragment with locking screws recessed into screw holes to create a lower profile distally. The angulation of these distal screws create a „scaffold“ to optimize subchondral bone

support with one or two screws devoted to fixation of the lunate facet and radial styloid. Most plating systems also feature an oblong hole for metaphyseal fixation and for plate positioning (25).

Several studies have compared outcomes of dorsal versus volar plating of distal radius fractures. Ruch and Papadonikolakis (29) performed a retrospective review of 34 patients, 20 of whom had undergone dorsal plating and 14 of whom had volar plating. The authors



Fig. 8. Complication of volar plate with screw too long resulting in extensor pollicis rupture requiring reconstruction.



found that both groups of patients had similar DASH scores, but the functional outcome in terms of Gartland and Werley scores was better in the volar plating group. In addition, there was a higher rate of volar collapse and late complications in the dorsal plating group compared with the volar plating group.

Volar plating, however, is not without its complications. Rozental and Blazar (28) retrospectively reviewed a cohort of 41 patients with dorsally displaced fractures treated with volar plating. Though Gartland and Werley scores were overwhelmingly good and excellent, 9 complications were noted. Four of these patients actually experienced loss of reduction and fracture collapse following volar plating (Fig. 8).

#### OPEN REDUCTION INTERNAL FIXATION: FRAGMENT SPECIFIC

The concept of fragment specific fixation has been touted as a surgical alternative to volar plating alone. Some basic tenets of fracture fixation for fragment specific systems include: (1) application of small contoured plates on the specific components of the fracture;

(2) fixation of distal fragments is based on the strong bone proximally; (3) hardware should allow for gliding motion of tendons; (4) the exposure should cause minimal soft tissue disruption; and (5) the fracture should be stable to allow early range of motion. The type of implant used should match the specific fracture fragment being reduced via the use of limited volar and dorsal incisions (Fig. 9a–c).

Schnall et al. (30) documented their early findings with fragment specific fixation in a retrospective study of 18 patients with intraarticular fractures. At 6 weeks, none of the patients demonstrated loss of reduction. At 6 months, patients demonstrated an average of 52 degrees of wrist flexion and 55 degrees of wrist extension. Grip strength was measured to be approximately 55 pounds. Two of the 18 patients required hardware removal for extensor tendon irritation.

Similarly, Rikli and Regazzoni (27) reviewed a series of 20 patients with distal radius fractures fixed with two 2.0 mm titanium plates placed at 50 – 70 degrees to one another. No cases of extensor tendon problems were noted, most likely because they were able to place a flap of retinaculum over the small dorsal plates. Clearly, fragment specific fixation may provide some advantages over the traditional methods of dorsal or volar plating for fractures at the distal end of the radius ( Fig. 10 a-c).

#### INTRAMEDULLARY FIXATION

Intramedullary fixation of fractures is not a new concept in orthopaedic trauma surgery. Intramedullary devices increase fracture stability of the affected bone, allow load transfer across the fracture site, minimize soft tissue problems by minimizing scarring and adhesions, and maintain vascular blood supply to promote fracture healing. Two implants have recently been desc-





Fig. 10 a-c. A complex intraarticular fracture: a. The preoperative x-rays and CT scans; b. Operative fixation with small Synthes plates and postoperative CT scan; c. Functional follow up and follow up x-rays

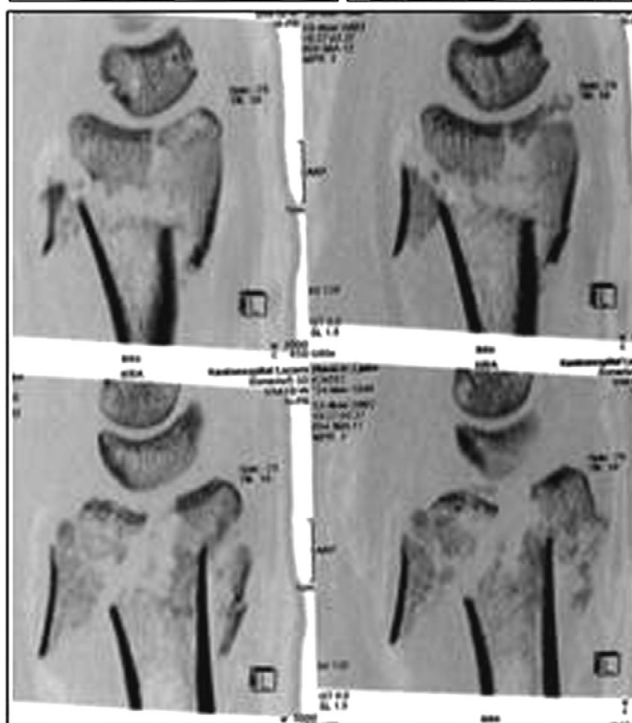


Fig. 10a ◀▼

Pokračování Fig. 10b ▶

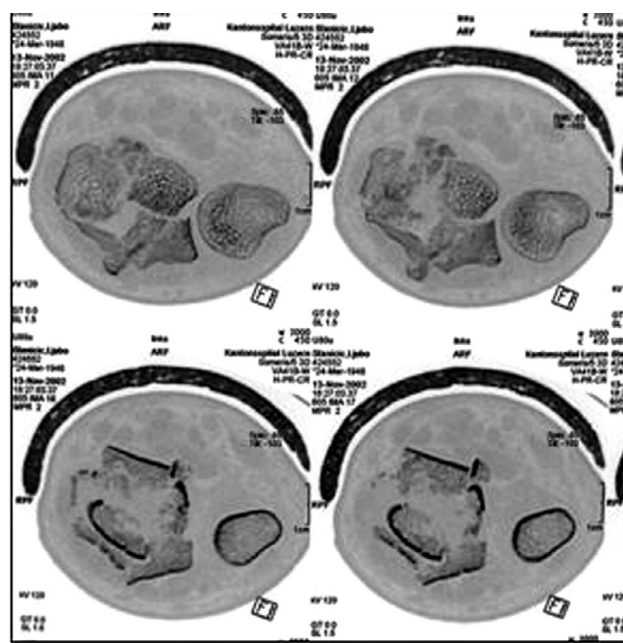






Fig. 10b ◀▶

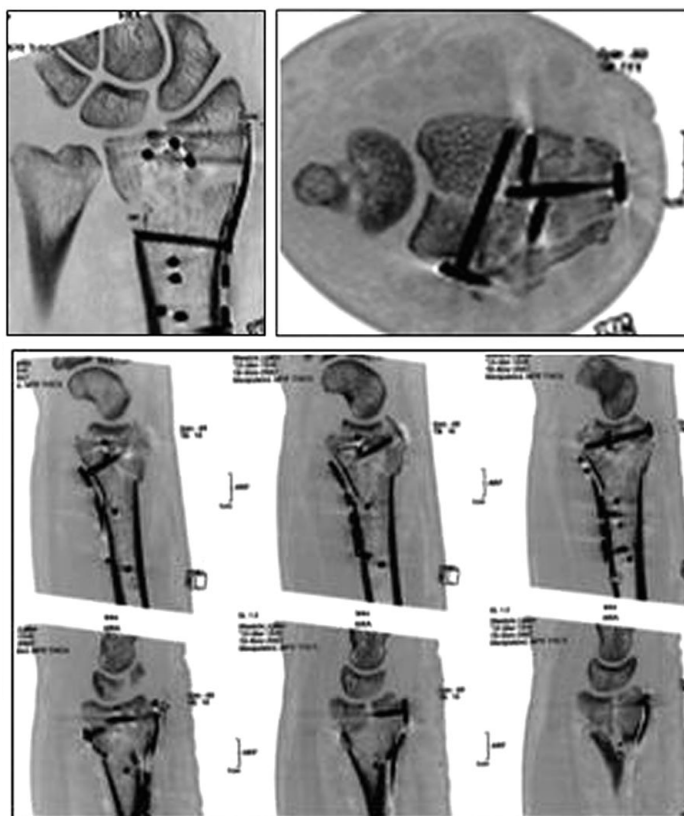


Fig. 10c ▼



ribed for use in the distal radius, namely the Micronail (Wright Medical Technology Inc., Arlington, TN) and the Dorsal Nail Plate (Hand Innovations LLC, Miami, FL). Both are used for metaphyseal distal radius fractures with minimal articular involvement.

The Micronail is placed through an incision made over the radial styloid, taking care to avoid injury to branches of the radial sensory nerve. The interval between the 1st and 2nd dorsal extensor compartments is used. Kirschner wires may be used for temporary fixation of large articular fragments. Difficulties that have

been described with use of this nail include possible soft tissue irritation with placement of the interlocking screws, possible screw penetration into the distal radioulnar joint, and difficulty observing sagittal alignment secondary to use of the jig (31).

Tan et al. (32) presented their experience with the Micronail in 23 patients with isolated unstable distal radius fractures. The minimum follow-up was 6 months. Range of motion and grip strength parameters were noted at 1 month and 6 month follow-up. The authors found that all wrist and forearm range of motion

parameters improved significantly from 1 month to 6 months. Grip strength also improved significantly from 40% to 80%. Three of the 23 patients had some loss in initial reduction, and one patient ultimately required conversion to open reduction and internal fixation.

The Dorsal Nail Plate is a hybrid plating and intramedullary device, again intended for fractures with minimal articular involvement. The approach is performed through a limited dorsal incision centered over the extensor pollicis longus. Lister's tubercle is removed, and the exposed bone is the insertion point of this intramedullary device. To our knowledge, outcomes with this device have not been reported. Orbay et al. (26) reported their technique and noted that complications were relatively infrequent with satisfactory functional results in over 200 patients.

### BIOABSORBABLE IMPLANTS

Another emerging technology for treatment of distal radius fractures is the use of bioabsorbable implants. While popular in the use of sports medicine procedures, bioabsorbable implants have seen limited applications in orthopaedic trauma procedures. The plates and screws in bioabsorbable constructs are typically made of polylactic acid or polyglycolic acid.

The Inion OTPS Hand System (Inion Inc, Oklahoma City, OK) is the only known bioabsorbable distal radius plate which is commercially available. This plate takes at least two years to degrade completely within the body, is contourable after placing in a hot water bath, and accepts polyaxial locking screws up to 20 degrees.

The advantages to using a bioabsorbable implant are manifold: Bioabsorbable distal radius plates obviously undergo resorption and obviate the need for hardware removal in the future, making revision surgery potentially less complicated. The implants also do not incite an inflammatory response and are MRI compatible. Bioabsorbable devices are, however, relatively new and unproven technology for fracture fixation. There are valid concerns regarding the initial fixation strength, and most of these implants are slightly thicker than their metal counterparts. Finally, one cannot visualize the implants on radiographs.

There is only one study, to our knowledge, which explores the possibility of using bioabsorbable implants for distal radius fracture fixation. One hundred patients with distal radius fractures were queried regarding implant preferences after they were given a brief summary of advantages and disadvantages of bioabsorbable and metal implants. The results of the questionnaires demonstrated that 95% preferred bioabsorbable implants for their absorption feature. 91% cited hardware removal as the most negative aspect of metal hardware. 80% of patients stated they would be interested in participating in a clinical trial comparing the two implants, setting the stage for a prospective randomized study (24).

### CONCLUSION

How aggressively we pursue reconstruction of distal radius fractures is dictated by the demands of the patient and radiographic findings at the time of injury. Nonoperative treatment is best reserved for low demand patients or patients too infirm to ably tolerate surgery. A multitude of different techniques can be utilized for fixation of distal radius fractures. Orthopaedic and upper extremity surgeons who manage these injuries should have all of these techniques at their disposal. As our experience with volar plating and fragment specific fixation continues to deepen, newer techniques and approaches become available but are still unproven.

### ZÁVĚR

Léčba zlomenin distálního radia je stále výzvou pro ortopedy i traumatology. S tím, jak se zlepšují naše znalosti anatomie a mechanismu poranění této oblasti, zdokonalují se i chirurgické postupy přispívající k obnově funkce postižené končetiny. Tato práce podává přehled současných metod léčby zlomenin distálního radia.

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