Fractures of the distal radius often have been considered primarily extra-articular injuries of elderly females. However, there are increasing reports of distal radial fractures causing serious articular damage and profoundly affecting the wrists of a greater population.\cite{3,6,8,10,17} Clearly, the distal radial articulations of younger patients are being exposed to increasingly severe trauma.

Better understanding of the spectrum of distal radial fractures is leading to changing concepts of management. Basic among these is the need to differentiate the more serious articular fractures from the extra-articular injuries commonly called Colles’ and Smith’s fractures. First, the articular injuries are more frequently comminuted, unstable, and less suitable for traditional methods of closed manipulation and cast immobilization. Second, the articular fractures are associated with a significantly higher rate of complications,\cite{1,4,5,6,9,10,14} and it is increasingly clear that preservation of the distal radial articular surfaces is necessary for maximum recovery. Finally, the more severe articular fractures are frequently associated with other serious injuries, particularly injuries of the median nerve, ulnar nerve, and flexor tendons.\cite{1,3,10,18,20,24} Maximum recovery requires not only precise correction of articular disruption but also prompt recognition and repair of any concomitant soft tissue or skeletal injuries.

Based on experiences with 330 articular fractures of the distal radius, this article defines more precisely the patterns of injury, proposes a classification to guide optimal treatment, and describes techniques that have proved consistently successful for the more complex injuries.

**DESCRIPTION OF ARTICULAR FRACTURES**

**Mechanism of Injury**

Tension, usually hyperextension, is commonly considered the major force causing fractures of the distal radius. However, compression is an
Figure 1. A and B, The articular fracture comprises four basic components: (1) radial shaft; (2) radial styloid; (3) dorsal medial fragment; and (4) palmar medial fragment. Displacement of the key medial fragments profoundly affects both the radiocarpal and distal radioulnar joints.

Equally important, or perhaps even more significant, force causing articular fractures. In their descriptions of distal radial fractures, Stevens and Scheck compared the lunate to a die punch, compressing and disrupting the articular surface of the radius. Undoubtedly, a compression force transmitted primarily by the lunate accounts largely for the fracture planes that occur across the distal radial articular surfaces.

Fracture Components

Despite a variable degree of comminution, the articular fracture comprises four basic fragments: (1) radial shaft; (2) radial styloid; (3) dorsal medial fragment; and (4) palmar medial fragment (Fig. 1). Owing to their critical position as the cornerstone of the radiocarpal and distal radioulnar joints, the medial fragments have a profound effect on normal wrist mechanics. Even minor displacement of these key fragments may seriously disturb the distal radial articulations.

Radiographs of articular fractures consistently demonstrate a transverse fracture line, separating the shaft from the medial and styloid fragments, at or just proximal to the sigmoid notch of the radius. This fracture plane results from the tension component of the injury and extends across the distal radial metaphysis. Although the fracture plane is predominantly extra-articular, it frequently extends into the sigmoid notch and contributes to articular disruption. From this, a second fracture line, resulting from compression, extends distally and vertically into the radiocarpal joint. This usually occurs in the area of the scapholunate articulation and separates the medial fragments from the styloid fragment. A third fracture line, best seen on the
ARTICULAR FRACTURES OF THE DISTAL RADIUS

Figure 2. Compression of the distal radius results in four basic fracture types and predictable patterns of displacement. A major compression force causes wide separation of the palmar and dorsal medial fragments (type IV) and serious disruption of the distal radial articulations.

Lateral radiograph, extends horizontally across the lunate fossa of the distal radius. This fracture may be in either the dorsal or the palmar aspect of the articular surface, depending on the direction of force and the site of lunate impact. Severe compression in this plane causes separation of the palmar and dorsal medial fragments and serious disruption of both the radiocarpal joint and the distal radioulnar joint (Fig. 2).

Although the components of the articular fracture are quite consistent, variations in the basic patterns may occur. For example, if the mechanism of force is primarily compression, the medial corner of the radius is most severely affected. This may result in only a three-part fracture with separation of the medial fragments from each other and from the radial shaft and styloid, which remain as a unit. Without a tension force, a transverse fracture across the distal radial metaphysis is less likely to occur. Similarly, if the mechanism is primarily tension, the major fracture plane will occur across the distal radial metaphysis with variable and possibly minor involvement of the radioulnar and radiocarpal joints. The type and direction of force account for the diversity of articular fractures.

Fracture Displacement

Instability of the fracture fragments results in basic patterns of displacement (see Fig. 2). Most commonly, the medial fragments are displaced as...
a unit. However, because compression by the lunate is usually in a posterior direction, the dorsal medial fragment is impacted more than the palmar medial fragment, and the lateral radiograph demonstrates typical posterior displacement. In his study of distal radial fractures, Scheck consistently observed this pattern of displacement and referred to the dorsal medial component as the "die punch" fragment. Less commonly, a force in an anterior direction results in greater compression of the palmar medial fragment, and anterior displacement is demonstrated on the radiograph (see Fig. 7). This pattern of articular displacement is commonly referred to as a Smith type II fracture, a Barton fracture-dislocation, or a reverse Barton fracture. As in this case, the traditional eponyms associated with distal radial fractures can be a source of confusion in diagnosis and management. An accurate description of the fracture components and displacement avoids confusion and is the preferred method of defining articular fractures.

Displacement of the medial fragments as a unit is occasionally associated with displacement of an additional fragment from the comminuted radial shaft (see Fig. 2). The fragment may be displaced at the time of injury or at the time of fracture manipulation. Typically, it rotates into a vertical position and projects as a spike into the flexor compartment of the wrist, causing injury to the median nerve or flexor tendons. Less frequently, a dorsal spike fragment is encountered, but displacement is usually minimal and acute extensor tendon injury is uncommon.

The most severe type of displacement is that of splitting, with wide separation of the medial fragments (see Fig. 2). This always results from a major compression force, which is usually generated by a serious athletic injury, a fall from a great height, or a high-speed vehicular accident. One fragment, usually the palmar medial one, may rotate as much as 180°, resulting in a marked disruption of the articular surfaces. This pattern occurs only with serious concomitant soft tissue damage, often with injury to the median or ulnar nerves as well as the flexor tendons.

Ligament Components

The carpus is nearly always displaced with one or both of the medial fragments owing to exceptionally strong soft tissue attachments. Personal studies of 20 cadaver wrists confirm this clinical observation (Fig. 3). The medial fragments are connected to the ulnar styloid by the triangular fibrocartilage, to the triquetrum by the ulnocarpal meniscus, and to the lunate by the ulnolunate ligament, as well as the strong dorsal and volar or capsular ligaments. These ligaments collectively constitute a major part of the ulnocarpal complex of the extrinsic wrist ligaments, described in detail by Talleisnik.

DePalma demonstrated experimentally that even with the most severely comminuted fractures, the ligaments of the wrist remain intact. The strength of these ligaments is of obvious clinical importance because their integrity permits the successful use of traction to maintain reduction of many of the complex articular fractures. In addition, the strength of the triangular fibrocartilage accounts for the frequency of ulnar styloid fractures in association with distal radial articular fractures. Many years ago, Stevens stated that the ulnar styloid fracture results from a force transmitted through an
nate is usually in a posterior direction more than the palmar direction. Scheck consistently referred to the dorsal medial fragment on the radiograph, which is commonly referred to as a valgus, or a reverse Barton type of fracture. Diagnosis and management of the injury may vary depending on the fragment's displacement.

Unit is occasionally associated with comminuted radial fractures. Less frequently, a placement is usually minimal, as that of a splitting with wide surfaces. This pattern occurs with one or both of the medial tissue attachments. Personal observation (Fig. 3). The styloid by the triangular fibrocartilage occurs secondarily to the major fracture, which is that of the radius. This concept is borne out by this study, in which 90 per cent of unstable articular fractures were found to have associated ulnar styloid fractures. The ulnar styloid fracture and, significantly, its frequent failure to unite do not seem to affect the prognosis, provided the major articular fracture is treated successfully.

**CLASSIFICATION**

There is need for a practical classification of fractures of the distal radius to guide optimal treatment. This is borne out by the wide variation in results of treatment reported for these injuries. From their classic description, neither Colles' nor Smith's fractures are intra-articular and thus should be excluded from discussion or series including the more complex articular distal radial fractures.

The classification used in this study is a modification of that proposed by Gartland and Werley. They stressed the frequency of articular involvement and its being the major determinant of the prognosis. The classification presented here developed from the observation that components of articular fractures consistently fall into four basic parts: (1) radial shaft; (2) radial styloid; (3) dorsal medial fragment, and (4) palmar medial fragment. The medial fragments and their strong ligamentous attachments with the proximal carpals and the ulnar styloid have been termed the *medial complex* (Fig. 4). Displacement of the medial complex is the basis for classification of articular fractures into four types (see Fig. 2).

**Type I**

These fractures are undisplaced or demonstrate variable displacement of the medial complex as a unit. Regardless of displacement, these fractures are not comminuted, and they are stable after closed reduction.
Type II (Die Punch Fractures)

These are unstable fractures with moderate or severe displacement of the medial complex as a unit. The hallmark of the unstable fracture is comminution of both the posterior and anterior cortices of the radius. This is often associated with three other characteristic radiographic features: (1) separation of the medial from the styloid fragments; (2) radial shortening greater than 5 to 10 mm; and (3) considerable angulation, usually exceeding 20°. The presence of comminution, particularly of the anterior cortex, should alert the examiner to the probability of instability. Fractures that initially appear to be stable have been observed to become displaced as late as 14 days following injury.

Type III (Spike Fractures)

These are unstable fractures that demonstrate displacement of the medial complex as a unit as well as displacement of an additional spike fragment from the comminuted radial shaft. As previously stated, the spike fragment characteristically projects into the flexor compartment of the wrist and causes injury to adjacent nerves or tendons.
CHARLES P. MELONE, JR.

GULAR CARTILAGE

TRIQUETRUM

ULNO-CARPAL MENISCUS

ULNO-LUNATE LIG.

LUNATE

RADIO-CARPAL LIG.

SCAPHOLUNATE LIG.

SCAPHOID

RADIO-CARPAL LIG.

ARTICULAR FRACTURES OF THE DISTAL RADIUS

Table 1. Unstable Fractures: Concomitant Injury

<table>
<thead>
<tr>
<th>CONCOMITANT INJURY</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>TOTAL</th>
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<td>3</td>
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<td>22</td>
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<td>0</td>
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<td>1</td>
</tr>
<tr>
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<td>0</td>
<td>4</td>
<td>7</td>
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<tr>
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<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
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<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
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<td>0</td>
<td>3</td>
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<tr>
<td>Scaphoid fracture</td>
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<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ulnar head fracture</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

*Number of fractures

Type IV (Split Fractures)

These are unstable fractures in which the medial complex is severely compressed by the lunate, resulting in wide separation or rotation of the dorsal and palmar medial fragments. The injury causes a major biarticular disruption and is always accompanied by serious soft tissue damage.

The exact fracture type cannot always be determined by the initial radiographs and may become apparent only after an attempt is made to reduce the fracture. This is especially true for the type II fracture, in which instability due to comminution of both radial cortices is demonstrated most clearly on the postreduction radiographs. Furthermore, there are instances when displacement of a comminuted spike fragment (type III) becomes obvious only after reduction and other instances when the severity of splitting or rotation of the medial fragments (type IV) is not apparent until closed reduction or traction is unsuccessful. In such cases, the unsuccessful reduction indicates an increasing complexity of injury and the need for more precise treatment.

TREATMENT

The primary goal of treatment of articular fractures of the distal radius is an accurate and stable reduction of the medial complex. This is essential for preservation of both radiocarpal and radioulnar joints and may require open treatment. In addition, because the unstable fractures are frequently complicated by serious concomitant injury (Table 1), optimal treatment requires prompt repair of many of these injuries.

Accuracy of Reduction

Personal experience with over 300 articular fractures supports the general opinion that the success of recovery parallels the accuracy of the reduction. Although there are exceptions of unsatisfactory reduction resulting in satisfactory function, malunion should be recognized as the common factor predisposing to poor results. Undoubtedly, complications are less likely to occur with prompt and precise fracture reduction.

Traditionally, measurements of radial length on the posteroanterior ra-
The major disturbance of the articular fracture occurs between the medial corner of the radius and the ulnar head. This articular fracture resulted in 5 mm of shortening of the medial complex (positive ulnar variance), but, characteristically, it did not affect the radial styloid-ulnar head distance. The most precise measurement of the accuracy of reduction is the vertical distance between the distal ends of the medial corner of the radius and the ulnar head.

These measurements have been useful guidelines for treatment of distal radial fractures. However, the major disturbance of the articular fracture occurs between the medial corner of the radius (not the radial styloid) and the ulnar head. Even minimal displacement of the medial complex results in disruption of the radiocarpal joint and subluxation of the radioulnar joint. Moreover, severe displacement of the medial complex resulting in disruption of the radial articular surfaces may not affect the distance between the radial styloid and the ulnar head. Therefore, a more precise measurement of the accuracy of reduction of articular fractures is the vertical distance between the distal ends of the medial corner of the radius and the ulnar head (Fig. 5). This is the same measurement, referred to as ulnar variance, used extensively in the evaluation of Kienböck's disease.

In the majority of people, the ulnar head and the medial corner of the radius are at the same level bilaterally (neutral variance). However, with fracture displacement, this relationship is disturbed and the ulnar head is in a distal position relative to the medial complex (positive variance). Clinical experience bears out that a discrepancy of 5 mm or more in length can profoundly affect wrist function, and because even the most accurate and stable reductions ultimately collapse several millimeters owing to impaction of comminuted fragments, an accurate reduction should restore the preinjury relationship between the medial complex and the ulnar head. Obviously, comparison radiographs of the uninjured wrist are necessary to determine normal length and to minimize misinterpretation due to normal variations.
The major disturbance of the articular fracture occurs between the medial radius and the ulnar head. This is resulted in 5 mm of shortening of the radial ulnar complex (positive ulnar variance), characteristically, it did not result in the ulnar styloid-ulnar head distance.

Cise measurement of the vertical distance between the ulnar head is the vertical distance between the ulnar head and the ulnar head. The values are 9 to 14 mm of radial length is usually shorter than the ulnar length and the ulnar head result in a loss of 6 mm of length if the ulnar head.

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Radial length is usually shorter than the ulnar length and the ulnar head result in a loss of 6 mm of length if the ulnar head.

Type I Fractures

Undisplaced fractures are best managed by 3 to 4 weeks of short arm splint or cast immobilization and, most importantly, early wrist motion when the fracture is sufficiently healed, as determined by clinical examination. Active and unrestricted digital, elbow, and shoulder motion is encouraged immediately after injury and immobilization of the fracture.

Reduction of displaced fractures is facilitated by regional or local anesthesia and sedation. Under sterile conditions, aspiration of the fracture hematoma and injection of 3 to 5 ml of 2 per cent Xylocaine constitute an effective and safe method of anesthesia. The criticism that this technique converts a closed fracture into an open fracture and increases the risk of infection is not supported by clinical experience.

Correction of the usual posterior displacement is achieved by steady traction, followed by palmar flexion of the wrist, ulnar deviation, and pronation. Effective cast immobilization must maintain reduction and, by incorporating the base of the thumb and the humeral epicondyles, eliminate potentially deforming forces across the fracture. The wrist is carefully mobilized in mild positions of flexion, ulnar deviation, and pronation. Although positioning in pronation is controversial, its efficacy is in approximation of the anteriorly displaced ulnar head to the posteriorly displaced medial complex. Extreme positions of immobilization, particularly excessive palmar flexion (the Cotton-Loder position), are associated with a high incidence of median nerve compression and joint contractures and should be avoided.

A satisfactory reduction requires restoration of normal radial length (usually neutral variance) and stability provided by accurate apposition of the anterior cortices of the radius. Invariably, the dorsal cortex is comminuted, and stability of the reduction hinges on the buttress of a relatively intact anterior cortex. If both cortices are extensively comminuted, the fracture is unstable, and collapse with loss of reduction is inevitable (Fig. 6). In such cases, closed reduction and cast immobilization are insufficient treatment. Multiple attempts at reduction are pointless and potentially harmful.

Anterior displacement of the medial complex is usually associated with extensive comminution and is less suitable for closed manipulation. Although reduction by supination of the wrist may be successful for the less comminuted injuries, manipulation of the distal fragments, particularly the palmar medial fragment, is extremely difficult and usually unsatisfactory. It is important to recognize that dorsiflexion of the wrist does not correct anterior displacement but rather increases lunate compression of the medial complex, resulting in persistent and possibly further displacement. Articular fractures with anterior displacements are usually type II injuries or, less frequently, type IV injuries and should be treated accordingly (Fig. 7).

Type II Fractures

There is general agreement that continuous skeletal traction is necessary to maintain a stable reduction of type II fractures. Despite an accurate reduction, these unstable injuries are prone to redisplacement, often to the prereduction position.
Figure 6. A and B, Articular fracture with excessive shortening of the medial complex and extensive comminution of both posterior and anterior cortices. Despite a seemingly successful closed manipulation (C and D), collapse with loss of reduction is inevitable (E). This is an unstable type II fracture, and traction is the preferred method of treatment.
Most articular fractures with anterior displacement are type II injuries and can be treated successfully with traction. A and B, Type II fracture with displacement of the palmar medial fragment. C and D, Successful reduction with traction and excellent preservation of the joint surfaces.

Figure 7. Most articular fractures with anterior displacement are type II injuries and can be treated successfully with traction. A and B, Type II fracture with displacement of the palmar medial fragment. C and D, Successful reduction with traction and excellent preservation of the joint surfaces.
Figure 8. Pins and plaster technique. A, The distal pin is passed through the base of the index and middle metacarpals, and the proximal pin is passed through the radius. Inset, The proximal pin must securely engage both cortices of the radius but avoid the critical soft tissue of the forearm. B, An unstable type II fracture treated with traction. C and D, The postreduction radiographs demonstrate distraction of the medial complex and accurate restoration of its articulations. E, At 7 weeks, fracture healing with maintenance of reduction and preservation of the articulations.
on the strength of the ligament component of the medial complex. The critical soft tissue attachments remain intact regardless of the severity of the fracture.

In my experience, fixation with pins and plaster, using two percutaneous \( \frac{3}{8} \)-inch smooth Steinmann pins incorporated in a short arm cast, is a consistently successful method of traction (Fig. 8). However, it is emphasized that success depends on precise technique and requires the use of a power drill. A variable-speed drill facilitates atraumatic and accurate pin placement, avoids reaming of the pin holes, and undoubtedly minimizes complications such as pin loosening and fracture at the site of pin insertion.

The distal pin is passed transversely through the base of the second and third metacarpals. During placement of this pin, the thumb is held in wide palmar abduction and the width of the palm is maintained in order to prevent the development of web space contractures. The radius rather than the ulna is preferred for placement of the proximal pin because it provides better control of the fracture and interferes less with elbow function. The site of insertion is just proximal to the abductor pollicis longus muscle in the interval between the wrist and finger extensors. The proximal pin is placed perpendicular to the distal pin and engages both cortices of the radius. Projection of the pin several millimeters beyond the anterior cortex of the radius provides a firm purchase in the bone and avoids the critical soft tissues of the forearm.

The hand is suspended by a traction bow attached to the metacarpal pin, and with the elbow flexed to 90°, a 2- or 3-kg counterweight, suspended by a sling, is applied to the arm. In a short period, the operative radiograph usually demonstrates distraction of the medial complex and accurate resto-
of its articulations. If there is residual angulation, gentle manipulation—usually flexion and pronation—completes the reduction.

Following an accurate reduction, the pins are incorporated in a short arm cast, which is carefully applied leaving the fingers and thumb free for immediate active motion. The wrist is positioned in slight flexion and the forearm in mid-rotation. Once the fracture is stabilized, neither pronation nor supination influences displacement of the key medial fragments because they are free of muscle attachments. When the plaster is hard, the traction bow and weights are removed, and the patient is strongly urged to begin active motion of the digits. Immobilization is continued for at least 6 weeks or until the comminuted fragments are completely healed. In the office, the cast and pins are removed, and a carefully planned program of therapy begins immediately. Over a period of several months, the patient progresses from active exercises to increasingly resistive exercises with weights. Steady improvement is expected for at least 6 months after removal of the cast.

Technical problems have occurred in only 3 of 70 type II fractures personally treated with pins and plaster. There was one instance of fracture redisplacement, which occurred when the pins were removed prematurely at 5 weeks. This patient later required an osteotomy, following which she regained satisfactory function. There were two instances of loosening of the proximal radial pin, one occurring 3 weeks after insertion and the other 6 weeks after insertion. The former case required placement of an ulnar pin for continuation of traction, but in the latter case, the fracture was healed and did not require further traction. Fracture displacement did not occur in either case. There was no instance of infection, soft tissue injuries, or fracture resulting from this method of percutaneous pinning and traction.

Concomitant Injury. Careful examination at the time of injury and before the administration of an anesthetic is necessary to detect nerve injury, which is prone to occur with type II articular fractures (see Table 1). Median and ulnar neuropathy is invariably associated with a marked displacement of the medial complex and severe disruption of its ulnar articulation. Characteristically, there is neurapraxia with loss of sensibility immediately after injury. In all cases, accurate closed reduction maintained by traction has been followed by complete recovery of nerve function over a period of 4 months.

Most of the serious concomitant skeletal injuries have occurred with type II fractures (Fig. 9). Scapholunate dissociation occurred with severely displaced fractures, and as expected (owing to soft tissue attachments), the lunate displaced with the medial complex while the scaphoid remained with the radial styloid. The carpal diastasis was corrected by reduction of the medial complex, the disrupted soft tissues of the scapholunate articulation healed during the period of traction, and no cases resulted in chronic carpal instability. Fractures of the distal ulna with displacement of the ulnar head and scaphoid fractures were also associated with the more severe type II injuries. With the exception of one unstable scaphoid that required open reduction and internal fixation so that traction could be continued, concomitant skeletal injury was treated successfully by an accurate and stable closed reduction of the articular fracture. Significantly, in the entire group of un-
ngulation, gentle manipulations the reduction.

are incorporated in a short e fingers and thumb free for ned in slight flexion and the stabilized, neither pronation e medial fragments because e plaster is hard, the traction nt is strongly urged to begin continued for at least 6 weeks tely healed. In the office, the ed program of therapy begins i, the patient progresses fr ises with weights. Steady im-
der removal of the cast.

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of sensibility immediately after on maintained by traction, has ve function over a period of 4

al injuries have occurred with lation occurred with severely to soft tissue attachments), the ile the scaphoid remained with corrected by reduction of the of the scapholunate articulation cases resulted in chronic carpal displacement of the ulnar head l with the more severe type II le scaphoid that required open n could be continued, concom-

stable fractures, reconstructive surgery, including excision of the ulnar head, has been necessary in only one case.

Type III Fractures

The displaced spike fragment is usually excised in conjunction with soft tissue repair and skeletal fixation of the articular fracture. An anterior approach extending from the proximal palm across the carpal tunnel to the ulnar aspect of the wrist provides excellent exposure of the displaced fragment and the damaged soft tissues (see Fig. 11D). Stabilization of the articular fracture is achieved by either internal fixation using Kirschner wires or external fixation using pins and plaster.

**Concomitant Injury.** In all cases, the displaced spike fragment con-
fused and continually compressed the median nerve until it was excised (Fig. 10A and B). In no case was the nerve disrupted, and following a thorough decompression and over a period of 4 months, complete recovery was the rule.

In addition to the acute cases, two malunited type III injuries referred for secondary treatment were complicated by median neuropathy, again due to continuous compression by a displaced spike fragment. Both cases also demonstrated rupture of the flexor pollicis longus and flexor digitorum profundus tendons (Fig. 10C and D). The ruptures occurred at the unreduced spike fragment approximately 3 months after injury. Because of extensive
tendon damage, direct repair was impossible, and transfers were used to restore tendon function. Most probably, these tendon injuries could have been prevented by excision or replacement of the spike fragment at the time of injury.

Type IV Fractures

Traction cannot correct the separation or rotation of the medial fragments, and open treatment is necessary for repair of the articular surfaces as well as the frequently damaged soft tissue (Fig. 11). Typically, the palmar medial fragment is most severely displaced, and an anterior approach to the wrist is necessary for reduction and fixation. Extending the incision across the carpal tunnel provides complete exposure of the articular fragments. The four-part comminuted fractures are generally not suitable for rigid fixation, and stabilization with Kirschner wires is used most frequently. First, the medial fragments are reduced and fixed with wires; then they are carefully aligned with the other fragments and with the ulnar head. Preservation of the radiocarpal joint requires precise apposition of the medial fragments and the styloid, and preservation of the distal radioulnar joint requires relocation and stabilization of the ulnar head in the sigmoid notch of the reduced medial fragments. Fracture stability is achieved with a minimum of four transfixion wires. Following reduction and fixation, the wrist is immobilized in a short arm cast for 6 weeks.
A displaced spike fragment compressing the tip of forceps resulting in chronic pollicis longus tendon (FPL) and flexor tendon injuries could have of the spike fragment at the time or rotation of the medial fragment at the time of repair of the articular surfaces (Fig. 1). Typically, the palmar position of the medial fragments is used most frequently. First, external radioulnar joint requires read in the sigmoid notch of the ulnar head. Preservation of the tendons and ligaments is achieved with a minimum tension and fixation, the wrist is im-

**Concomitant Injury.** Median and ulnar neuropathy has been an exceptionally common occurrence with type IV fractures (see Table 1). The median nerve invariably has been injured at the level of the comminuted edge of the radial shaft, and in each case of ulnar neuropathy, the palmar medial fragment contused the nerve. In all but one case, prompt decompression, epineurotomy, and evacuation of a subepineural hematoma, in conjunction with fracture reduction and internal fixation, have been followed by steady and complete recovery of nerve function over a period of 4 to 5 months. The one case of complete median nerve disruption occurred in association with a laceration of the flexor pollicis longus tendon, also at the sharp edge of the radial shaft fragment. The nerve was repaired microscopically, and recovery was satisfactory.

In contrast to type II fracture neuropathy, which has improved spontaneously with successful fracture treatment, neuropathy associated with type III and type IV fractures requires thorough exploration and decompression, and possibly even nerve suture. However, all nerve injuries associated with the unstable articular fractures have demonstrated a similar and superior recovery of nerve function. Interestingly, none of the injuries required a secondary repair or neurolysis during a follow-up period as long as 7 years.

Injury of the flexor pollicis longus tendon is also prone to occur with type IV fractures. In all cases, the tendon has been lacerated at the sharp edge of the comminuted radial shaft fragment and has been repaired pri-
Charles P. Melone, Jr.

Figure 11 (Continued).  

D. An anterior approach to the wrist provides excellent exposure of the displaced fragments and the damaged soft tissues. Inset. Derotation and reduction of the palmar medial fragment restore biarticular congruity. E and F. Postoperative radiographs following open reduction and internal fixation with multiple Kirschner wires demonstrate excellent restoration of the distal radial articulations.

Treatment Overview

The McBride system of disability evaluation and the Lidström radiographic classification are the standard methods of analyzing the results of treatment. 1,5,7,9,10,14,16 Based on these criteria, a preliminary review of 85 unstable articular fractures leads to several conclusions. First, the classification proposed here serves as a useful guide for successful treatment. Second, an accurate and stable reduction of the medial complex consistently results in satisfactory and generally superior wrist function. Finally, despite extensive comminution and technical problems of internal fixation, the more complex articular fractures (type III and type IV) are most effectively treated by prompt and precise repair of the articular and soft tissue damage.
Charles P. Melone, Jr.

**ARTICULAR FRACTURES OF THE DISTAL RADIUS**

**SUMMARY**

Fractures of the distal radius are frequently articular injuries resulting in disruption of both the radiocarpal and distal radioulnar joints. The articular fracture comprises four basic components: (1) radial shaft; (2) radial styloid; (3) dorsal medial fragment; and (4) palmar medial fragment. The medial fragments and their strong ligamentous attachments with the proximal carpal and ulnar styloid have been termed the *medial complex*, and its displacement is the basis for a useful classification into four fracture types.

Type I fractures are undisplaced, or they are stable after closed reduction with preservation of the joint surfaces. Type II fractures are comminuted and unstable, with displacement of the medial complex as a unit, and are best managed with continuous skeletal traction. Type III spike fractures demonstrate displacement of the medial complex as a unit as well as displacement of an additional fragment from the comminuted radial shaft. The spike fragment characteristically causes injury to an adjacent nerve or tendon and requires excision or replacement along with repair of the soft tissue at the time of skeletal fixation. Type IV split fractures require open reduction and internal fixation for an accurate repair of the disrupted distal radial articular surfaces.

The unstable articular fractures are frequently associated with serious concomitant nerve, tendon, or skeletal injury, which must be recognized and often repaired at the time of fracture treatment. These injuries are usually the result of violent trauma, and contrary to common opinion, they do not characteristically occur among the elderly.

Optimal management of distal radial fractures requires early recognition and repair of articular disruption and any associated soft tissue or skeletal injury. Precise reduction of the medial complex consistently restores biarticular congruity and generally results in a superior recovery of wrist function.

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