© 2004 Lippincott Williams & Wilkins, Philadelphia

TECHNIQUE

Volar Fixed-Angle Fixation of Distal Radius Fractures: The DVR Plate

Jorge Orbay, MD, Alejandro Badia, MD, Roger K. Khoury, MD, Eduardo Gonzalez, MD, and Igor Indriago, MD
Miami Hand Center
Miami, FL

ABSTRACT

Volar fixed-angle fixation of distal radius fractures is a new method of treatment that provides the benefits of stable internal fixation without incurring the disadvantages of the dorsal approach. The DVR plate is a new fixation implant that was introduced specifically for the purpose of managing both dorsal and volar displaced fractures from the volar aspect. Experience gained applying volar fixed-angle fixation to clinically complex cases led to the description of a new surgical approach and to refinement in design of the implant. The need to reduce fractures with significant articular displacement and the need to debride dorsal organized hematoma or callus in old fractures led to the development of an extended form of the flexor carpi radialis approach that provides improved dorsal exposure by mobilizing the proximal radius out of the way and allows the use of the fracture plane for intrafocal exposure. The use of this implant in severely osteoporotic bone and in those fractures presenting severe articular fragmentation or displacement led to the improvement of its design. The plate's ability to stabilize the distal radius was optimized by taking full advantage of the principles of subchondral support and buttress fixation.
Keywords: distal radius fracture, volar approach, fixed-angle fixation, DVR plate

HISTORICAL PERSPECTIVE

The distal radius is the most common fracture site of the human skeleton, and until recently,[1] it has been a difficult area to treat with internal fixation. This difficulty resulted from the inability of conventional bone screws to obtain purchase in weak spongy bone and to its frequent fragmentation.[2,3] Open reduction and internal fixation followed by early motion, the gold standard of periarticular fracture care, was rarely recommended as a form of treatment of the most common type: the dorsally displaced distal radius fracture. This occurred despite the widespread knowledge of the importance of early motion in hand rehabilitation.[3] Internal fixation and early motion was commonly practiced only in fractures with volar displacement that were amenable to volar buttress plating. Fixation issues and the extensor tendon problems associated with the dorsal approach limited the routine application of conventional plate fixation to only these injuries.[4–11]

The introduction of fixed-angle internal fixation improved the surgeon's ability to manage complex periarticular fractures including those about the distal radius. This form of treatment does not depend on screw purchase for distal fragment support but rather on direct internal buttressing provided by the fixed-angle elements. The application of fixed-angle fixation to the distal radius was pioneered by Kambouroglou and Axelrod and by Jupiter et al,[5,12] who simultaneously developed both dorsal and volar fixed-angle plates. Shortly afterward, Medoff and Kopylov introduced "fragment specific fixation," which utilizes buttressed K-wires and small fixed-angle implants to provide stability through multiple combined surgical approaches.[13] Traditional surgical rationale was that dorsally displaced fractures were best approached from the dorsum and volarly displaced fractures using a volar approach.[10,14,15] Because of this reasoning, the more frequent dorsal fractures were treated through a dorsal approach with often disappointing results.[16] The dorsal approach to distal radius fractures has many inherent difficulties. The approach requires extensive dissection of the extensor tendon sheaths, resulting in subsequent scar formation and limitation of motion.[4] In addition, implants applied to the dorsum of the distal radius are in direct contact with extensor tendons, often resulting in tenosynovitis and, occasionally, tendon ruptures.[4–11] Dorsal dissection also devascularizes small comminuted cortical fragments,

Address correspondence and reprint requests to Jorge Orbay, MD, Miami Hand Center, 8905 SW 87th Avenue, Suite 100, Miami, FL 33176. E-mail: jlorbay@aol.com.

hindering the healing process and increasing the need for bone grafting.[17]

The extended flexor carpi radialis (FCR) approach was described to allow the surgeon to reduce complex dorsally displaced fractures through a volar exposure, and the DVR plate was designed for the purpose of stabilizing these fractures from the volar aspect.[18] The volar approach has many advantages. The exposure avoids dissection of extensor tendon sheaths and devascularization of dorsal fragments. The flexor tendons do not come in contact with a well-designed and properly applied volar plate due to the concave shape of the volar distal radius. Experience with the DVR plate has shown that it is effective in managing dorsally displaced distal radius fractures including intra-articular injuries and those in osteoporotic patients.[19] The design of the plate has evolved, and improvements have been added to better buttress volar marginal fragments and provide subchondral support to the central aspect of the articular surface. It is now possible to position the plate through the use of a fixed-angle provisional K-wire.

FIGURE 1. A good indication for this technique is a dorsally displaced, comminuted, and intra-articular fracture of the distal radius.

■ INDICATIONS/CONTRAINDICATIONS

This technique is indicated for unstable distal radius fractures in which simpler forms of treatment would produce unacceptable results. In general terms, these are the highly displaced, intra-articular, high-energy injuries and those with large metaphyseal defects. Articular fractures in young and active patients that need optimal restoration of the bony anatomy to prevent posttraumatic arthrosis, polytraumatized patients with complex rehabilitation issues that might include lower extremity injuries, and the elderly patient in need of quick return to functional independence are also indications for this technique.[19] We define fractures as unstable if, after an attempt at closed reduction, there is still greater than 15° of angulation in any plane, greater than 2 mm of articular step-off, or greater than 2 mm of shortening. Fractures with severe comminution, severe articular displacement, or poor bone quality are also considered unstable. Patients presenting with nonunions, old fractures, or nascent malunions can also be treated with this technique.

■ TECHNIQUE

Fixed-angle volar fixation of complex distal radius fractures (Fig. 1) is best performed through an incision placed directly over the course of the FCR tendon. This incision (FCR approach) is 8 to 10 cm long, zigzags across the wrist flexion creases, and reaches distally to the level of the tuberosity of the scaphoid (Fig. 2), a configuration that will place the midpoint of the incision directly over the fracture site. The superficial fascia is incised longitudinally, and the FCR tendon is retracted medially, protecting the median nerve. The floor of the sheath is then incised to gain deeper access; it should be divided distally up to the tuberosity of the scaphoid. This dissection is taken down to the surface of the distal radius by developing the space between the flexor pollicis longus (FPL) and the radial septum. The space of Parona, the virtual space between the flexor tendons and the volar surface of the pronator quadratus (PQ), is then developed. The most distal fibers of the origin of the FPL muscle may be released for proximal exposure. The PQ is mobilized by releasing its distal and lateral borders with an L-shaped incision (Fig. 3). The site for the transverse limb of this incision is determined by palpation of the volar rim of the lunate fossa. The PQ muscle is lifted from its bed by subperiosteal dissection to expose the fracture site.

A simple recent fracture (less than 10 days old) can

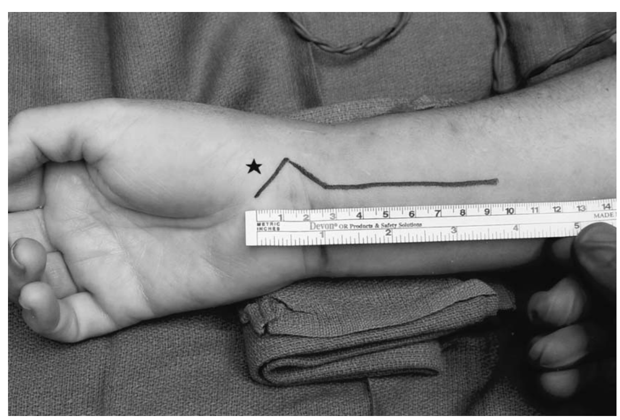

FIGURE 2. The incision for the extended FCR approach is 8 to 10 cm long, zigzags across the wrist flexion creases, and reaches distally to the level of the tuberosity of the scaphoid (★).

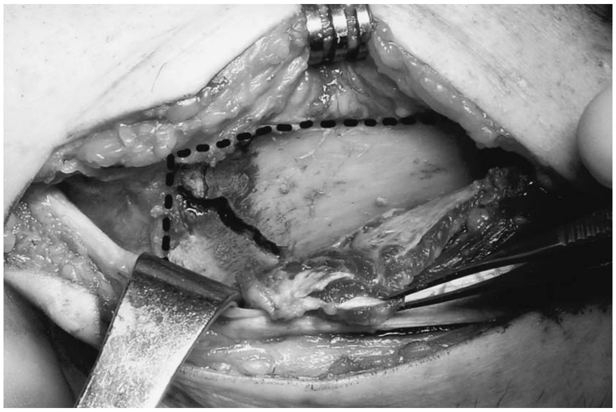

FIGURE 3. The pronator quadratus is lifted using an L-shaped incision. The transverse limb of the incision lies immediately proximal to the volar rim of the lunate fossa.

FIGURE 5. Pronating the proximal fragment provides the exposure necessary to manage complex articular or inveterate fractures. A free central articular fragment is shown as it is being reduced.

be treated with only the exposure described so far (standard FCR approach), as longitudinal traction in the presence of intact dorsal soft tissues can produce an adequate reduction by virtue of ligamentotaxis. On the other hand, a more complex fracture will require a more extensive exposure. The extended FCR approach provides this exposure by utilizing the fracture plane and rotating the proximal fragment out of the way into pronation. Prior to this maneuver, it is necessary to release the radial septum. This is a complex fascial structure that includes the first extensor compartment and the brachioradialis (BR). The BR tendon that inserts into the floor of the first extensor compartment (Fig. 4) should be frequently released, as it induces a major deforming force on the distal fragment. While exposing the radial metaphysis, it is important not to strip the soft-tissue attachments on its ulnar aspect, as perforators from the anterior interosseous artery are a major source of its blood supply. The extended FCR approach (Fig. 5) provides the exposure needed to debride fracture hematoma or fibrous callus and obtain reduction of complex fractures. Also, in the case of a true nascent malunion, the ossified callus and hypertrophic dorsal periosteum may be removed and bone graft applied through this approach. After fracture debridement, reduction of the articular surface fragments, and possibly bone grafting, the proximal radial fragment is supinated back into position. The final reduction is obtained mostly by indirect means such as traction and pressure on the dorsal skin. Application of the plate to the proximal fragment facilitates reduction by providing a template for restoration of volar tilt (Fig. 6), whereas length and radial tilt are judged by the congruity of the volar fracture lines. The DVR implant accepts fixed-angle K-wires that can provide temporary fracture fixation and allow the surgeon to visualize the plane of the proximal or primary peg row (Fig. 7). The

FIGURE 4. The brachioradialis inserts on the floor of the first extensor compartment (▲). Both structures are part of the radial septum (★).

FIGURE 6. The proximal radius is supinated back into place after fracture debridement; final reduction is obtained primarily by using indirect means such as traction and pressure on the dorsal skin. Application of the plate to the proximal fragment guides the restoration of volar tilt.

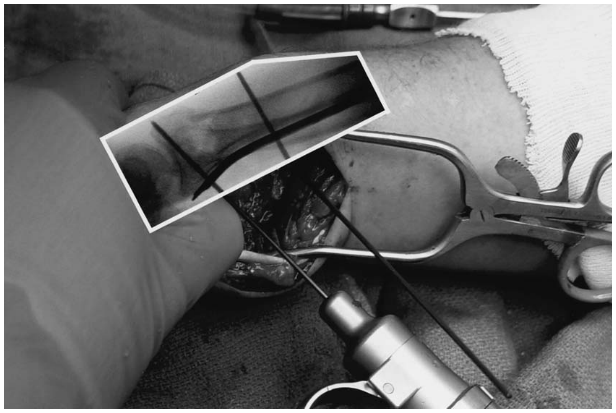

FIGURE 7. Fixed angle K-wires provide temporary fixation and allow the surgeon to visualize the plane of the primary peg row.

DVR plate has 2 rows of fixed-angle pegs that support distinct areas of subchondral bone and create a 3-dimensional scaffold that supports the entire articular surface. The plate also has an anatomically designed volar buttressing surface that projects over the volar marginal rim of the lunate fossa to better stabilize these problematic volar fragments (Fig. 8). The proximal or primary row is directed obliquely from proximal to distal to support the dorsal aspect of the articular surface; these pegs are most effective in preventing the redisplacement of dorsally displaced fractures. The distal or secondary row is directed in a relatively proximal direction and crosses the proximal row at a length of 18 mm. These pegs support the more central and volar aspect of the subchondral bone (Fig. 9). The primary row provides the stability necessary to manage most fractures. In cases with a significant volar marginal fragment, and in those with central articular comminution or severely osteoporotic bone,

FIGURE 8. The 2 peg rows on the DVR plate provide a 3-dimensional surface to support the subchondral bone. The implant also has an anatomically designed volar buttressing surface to stabilize volar fracture fragments.

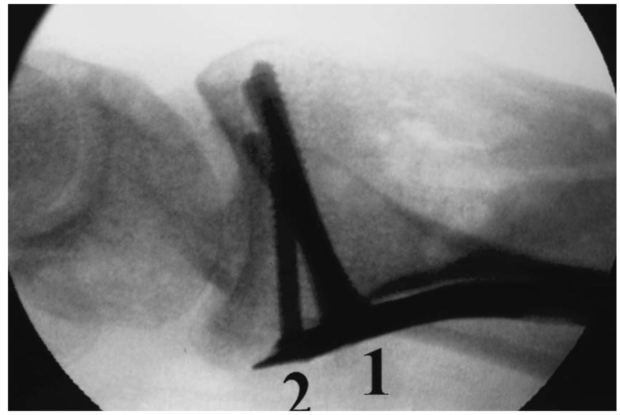

FIGURE 9. The proximal or primary peg row (1) supports the dorsal aspect of the subchondral bone, preventing redisplacement of dorsal fractures. The distal or secondary row (2) provides support to the central and volar aspect of the subchondral bone, stabilizing central articular and volar marginal fragments.

the secondary row of pegs provides improved fixation. Because the plate is very thin on its most distal aspect, it is necessary to countersink the cortex underneath the distal peg holes before threading the drill guide. In fresh fractures, it is easier to first apply the plate to the proximal fragment and then reduce the distal fragments to the implant. In some old fractures where there is considerable soft-tissue contracture, it might be easier to apply the plate to the distal fragment first.[17,20] The plate is guided down to the surface of the distal radius over a K-wire drilled parallel to the articular surface and inserted through a hole provided for this purpose (Fig. 10). The implant is fixed to the distal fragment and used as a lever to obtain reduction (Fig. 11). Reduction and device

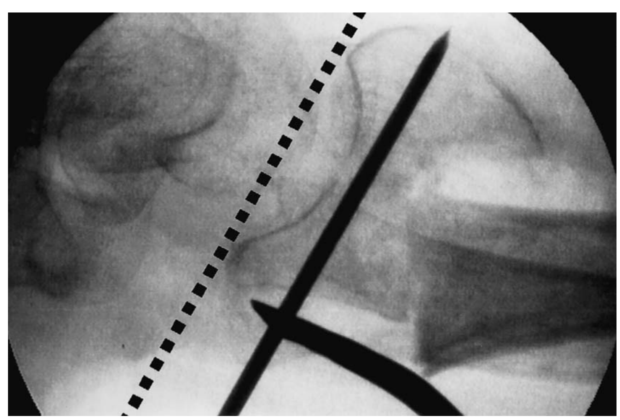

FIGURE 10. Applying the plate to the distal fragment first will facilitate reduction in fractures with extensive soft-tissue contracture. Lowering the plate onto the volar surface using a K-wire drilled parallel to the joint in the lateral plane and through a hole provided for this purpose will correctly align the plate to the distal fragment.

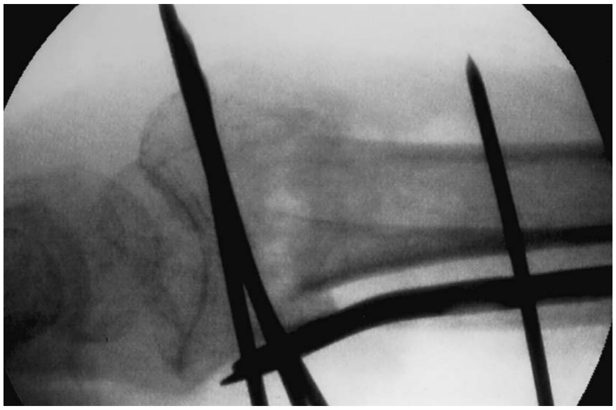

FIGURE 11. Once the plate is stably fixed to the distal fragment, it can be used as a lever to facilitate reduction.

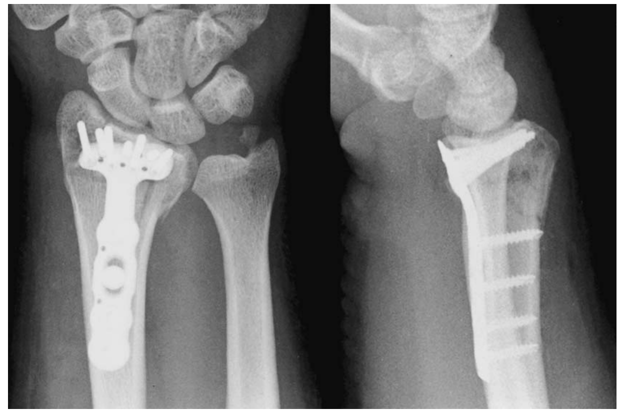

FIGURE 12. Reduction and hardware placement is examined using a lunate fossa or anatomic tilt lateral view (20–30°). This is necessary to confirm correct peg placement in the immediate subchondral position.

placement must be finally assessed radiographically, as it is impossible to see the articular surface from the volar aspect after reduction has been obtained. The articular surface must be examined using a lunate fossa or anatomic tilt[21] view to assure proper placement of the pegs in the immediate subchondral position (Fig. 12).

Internal fixation of an associated scaphoid fracture can be achieved by incising the volar capsule. Carpal tunnel release should be performed through a separate incision, as complete release of the radial insertion of the carpal ligament is associated with FPL dysfunction, and the palmar cutaneous nerve is at risk if the incision is extended ulnarly and distally into a standard carpal tunnel release. After fracture stabilization, the BR and PQ are repaired to retain the bone graft and to cover the implant (Fig. 13).

■ COMPLICATIONS

With vigilance and careful technique, most complications can be avoided. Flexor tendon problems can only occur if fracture reduction is lost, as a properly applied volar plate is recessed into the concavity of the volar radius and is not in contact with these structures. Dorsal tendon irritation can occur due to an excessively long peg. This problem is prevented by careful technique and should be treated with device removal. Full-blown reflex sympathetic dystrophy (RSD) is rare in patients treated with rigid internal fixation and early function. The milder forms of this disorder presenting as slow progress in rehabilitation or pain and swelling out of proportion to the injury are occasionally seen. These cases respond well to early treatment, which can include intensive physiotherapy, calcitonin, steroids, and sympathetic blocks.[7,15,17,22–24] Full digital motion should be expected by the end of the first postoperative week, and its absence is treated aggressively. Infection can occur following internal fixation, but this happens rarely in this anatomic region. Loss of reduction with the DVR plate is uncommon if proper technique is used. It is important to place the subchondral support pegs immediately below the subchondral bone in cases with severe osteoporosis or settling of the distal fragments onto the pegs can occur.[4,7] The implant is strong enough to tolerate the loads of early functional use of the hand but fatigue failure can occur if bone healing is prolonged excessively. It is important that clinical situations with impaired healing potential such as large metaphyseal defects, osteotomies, and nonunions be addressed by proper bone grafting. Autologous bone graft remains the choice material to date. Concomitant ligamentous injuries, both intercarpal and distal radioulnar, frequently occur. They should be looked for and treated early. Persistent pain long after a distal radius fracture can be due to one of these easily

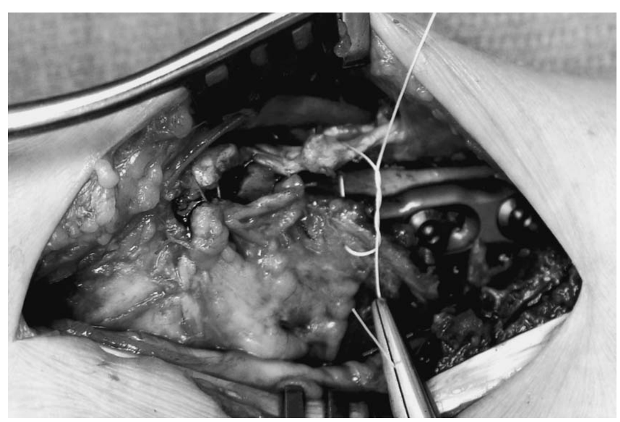

FIGURE 13. The brachioradialis and pronator quadratus are repaired, helping to retain the bone graft and providing coverage over the implant, as well as stabilizing the DRUJ.

missed injuries. Carpal tunnel syndrome and traumatic median neuropathies are not uncommon after distal radius fractures and should be managed diligently.[6,14,25–27]

REHABILITATION

Like in all hand injuries, proper rehabilitation is an essential part of treatment. Referral to a physiotherapist greatly facilitates the proper care of these patients. Instructions for elevation and finger motion should be given immediately after surgery. A custom-made, removable, short-arm splint will provide all the needed support after removal of the postoperative dressing. This splint should be removed at home to perform wrist motion exercises and for hygienic reasons. The use of the hand for light activities of daily living (ADLs) should be encouraged after the first postoperative visit, and patients can be given reasonable weight-lifting restrictions; usually a 5 pound limit is adequate for the affected wrist. This weight-lifting limit can be increased progressively, and no restrictions are required once radiographic union is achieved. Forearm rotation can be commenced at the first postoperative visit unless a concomitant distal or radial ulnar joint (DRUJ) instability problem requires its immobilization.

Although all fractures and all patients are different, full digital motion should be expected at the first postoperative visit or soon afterward. Recovery of full forearm rotation is slower and can take 4 to 6 weeks. A diligent therapist can greatly assist in the recovery of this function. Full wrist flexion and extension is a reasonable goal for most distal radius fractures treated with volar fixed-angle fixation; recovery of this motion usually progresses up to the third or fourth month, when a plateau is usually reached. Passive range of motion exercises do not seem to help in recovering this function and can produce undue swelling and pain. In general, wrist extension usually returns faster than wrist flexion. Fracture healing usually occurs between the 4th and 10th week. Extra-articular fractures generally have less soft-tissue swelling and a faster return of function, whereas intra-articular fractures often have more soft-tissue reaction and benefit from a more prolonged period of wrist splinting. In the latter, the priority is recovery of digital motion.

REFERENCES

1. Jakob M, Rikli DA, Regazzoni P. Fractures of the distal radius treated by internal fixation and early motion, a prospective study of 73 consecutive patients. *J Bone Joint Surg Br*. 2000;82B:340–344.
2. Bradway KJ, Amadio PC, Cooney WP. Open reduction and internal fixation of displaced, comminuted intra-articular fractures of the distal end of the radius. *J Bone Joint Surg Am*. 1989;71A:839–847.
3. Weber SC, Szabo RM. Severely comminuted distal radius fractures as an unsolved problem. Complications associated with external fixation and pin and plaster techniques. *J Hand Surg*. 1986;11A:156.
4. Fernandez DL. Should anatomic reduction be pursued in distal radial fractures. *J Hand Surg*. 2000;25B:1–6.
5. Kambouroglou GK, Axelrod TS. Complications of the AO/ASIF titanium distal radius plate system (π plate) in internal fixation of the distal radius: a brief report. *J Hand Surg*. 1998;23A:737–741.
6. Hove LM, Nilsen PT, Furnes O, et al. Open reduction and internal fixation of displaced intraarticular fractures of the distal radius, 31 patients followed for 3–7 years. *Acta Orthop Scand*. 1997;68:59–63.
7. Carter PR, Frederick HA, Laseter GF. Open reduction and internal fixation of unstable distal radius fractures with a low- profile plate: a multicenter study of 73 fractures. *J Hand Surg*. 1998;23A:300–307.
8. Fernandez D, Jupiter J. *Fractures of the Distal Radius: A Practical Approach to Management*. New York, NY: Springer; 1996:199.
9. Ring D, Jupiter JB, Brennwald J, et al. Prospective multicenter trial of a plate for dorsal fixation of distal radius fractures. *J Hand Surg*. 1997;22A:777–784.
10. Lucas GL, Feifar ST. Complications in internal fixation of the distal radius [letter]. *J Hand Surg*. 1998;23A:1117.
11. Kamano M, Honda Y, Kazuki K, et al. Palmar plating for dorsally displaced fractures of the distal radius. *Clin Orthop*. 2002;397:403–408.
12. Jupiter JB, Fernandez DL, Toh CL, et al. Operative treatment of volar intra-articular fractures of the distal end of the radius. *J Bone Joint Surg*. 1996;78A:1817–1828.
13. Medoff RJ, Kopylov P. Immediate internal fixation and motion of comminuted distal radius fractures using a new fragment specific fixation system. *Orthopaedic transactions*. 1998;22:165.
14. Trumble TE, Hanel DP, Geissler WB, et al. Intra-articular fractures of the distal aspect of the radius. *J Bone Joint Surg Am*. 1998;80A:582–599.
15. Axelrod TS, McMurtry RY. Open reduction and internal fixation of comminuted, intraarticular fractures of distal radius. *J Hand Surg*. 1990;15A:1–11.
16. Müller ME, Nazarian S, Koch P, et al. *The Comprehensive Classification of Fractures of Long Bones*. Berlin: Springer-Verlag; 1990.
17. Henry MH, Griggs SM, Levaro F, et al. Volar approach to dorsal displaced fractures of the distal radius. *Tech Hand Upper Extrem Surg*. 2001;5:31–41.
18. Orbay JL, Fernández D. Volar fixation for dorsally displaced fractures of the distal radius: a preliminary report. *J Hand Surg*. 2002;27A:205–215.
19. Orbay JL, Fernández D. Volar fixed angle fixation plate for

unstable distal radius fractures in the elderly patient. *J Hand Surgery*. 2004;29A:96–102.

20. Prommersberger KJ, Van Schoonhoven J, Lanz UB. Outcome after corrective osteotomy for malunited fractures of the distal end of the radius. *J Hand Surg*. 2002;27B:55–60.
21. Boyer MI, Korcek KJ, Gelberman RH, et al. Anatomical tilt x-rays of the distal radius: an *ex vivo* analysis of surgical fixation. *J Hand Surg*. 2004;29A:116–122.
22. Goldner JL, Urbaniak JR, Bright DS, et al. Sympathetic dystrophy-upper extremity: prediction, prevention, and treatment. *J Hand Surg*. 1980;5:289.
23. Leibovic SJ. Fixation for distal radius fractures. *Hand Clin*. 1997;13:665–680.
24. Seitz WH. fractures of the distal radius. In: Peimer CA, ed. *Surgery of the Hand and Upper Extremity*. New York, NY: McGraw-Hill; 1996:637–666.
25. Aro H, Koivunen T, Katevuo K, et al. Late Compression neuropathies after Colle's fractures. *Clin Orthop*. 1988; 233:217–225.
26. Cooney WP, Dobyns JH, Linscheid RL. Complications of Colle's fractures. *J Bone Joint Surg*. 1980;62:613–619.
27. Stewart HD, Innes AR, Burke FD. The hand complications of Colle's fractures. *J Hand Surg*. 1985;10B:103–106.