Distal Radius Fractures in a Functional Quadruped

Spanning Bridge Plate Fixation of the Wrist

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KEYWORDS

• Distal radius fractures • Functional quadruped • Spanning bridge plate fixation • Wrist

KEY POINTS

- Functional quadrupeds are patients who require full weight bearing with all 4 extremities in order to mobilize and bear weight.
- A functional quadruped can be someone who is walker dependent to mobilize or patients with polytrauma temporarily needing their upper extremities to bear weight and mobilize with crutches or a walker.
- In a functional quadruped, distal radius fractures can be treated with a dorsal spanning bridge plate for any fracture pattern to allow immediate unrestricted weight bearing with the injured upper extremity.
- In the authors' series, there were no cases of nonunions, tendon ruptures, or reoperations other than the planned staged bridge plate removal.
- Dorsal spanning bridge plate fixation of distal radius fractures in the functional quadruped is a viable treatment strategy for immediate weight bearing with the injured limb and, in the authors' series, demonstrates satisfactory results.

INTRODUCTION

The prevalence of distal radius fractures continues to increase as the average age of the US population increases.[1] Among patients more than 65 years of age, distal radius fractures account for 18% of all fractures.[2] Although there is an increasing trend toward treating distal radial fractures operatively, elderly patients are better able to tolerate malunion compared with younger patients relative to ultimate functional outcomes.[3–5] The treatment of distal radius fractures includes nonoperative treatment with splint or cast immobilization as well as multiple operative options with surgical fixation. Broadly, the indications for surgical fixation of a distal radius fracture include unstable and/or displaced fractures. However, additional surgical indications for distal radius fractures include polytrauma patients and walker-dependent elderly patients, both needing the use of their hands for weight bearing and mobilization, that is, a *functional quadruped*. A quadruped is an animal with 4 feet, and humans are, by definition, biped. However, patients with lower-extremity injuries and/or patients who normally depend on assistive devices, such as a walker, are essentially a functional quadruped, as they require all 4 limbs in order to mobilize and ambulate.

A functional quadruped with a distal radius fracture, irrespective of fracture pattern specifics,

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poses a unique challenge. Standard surgical fixation options of the distal radius include closed reduction and pinning with casting, external fixation, fragment-specific fixation, intramedullary nailing, and various plating options, including volar, dorsal, and radial plates.[6] However, except for external fixation, the other surgical options for the distal radius do not necessarily afford immediate weight bearing with an assistive device like a cane, crutch, or walker. In these settings, an alternative surgical fixation option is the use of a spanning dorsal bridge plate.[7,8]

The concept of dorsal spanning or bridge plate fixation of distal radius fractures is not new and was initially described to manage either highly comminuted fractures of the distal radius and/or serve as an alternative to cases requiring prolonged external fixation as an internal fixator instead.[7,9] This technique has evolved, and its indications have expanded to include polytrauma patients with the particular goal of earlier weight bearing with the injured upper extremity and improved rehabilitation.[10] The traditional technique used an Association for Osteosynthesis (AO)/Association for the Study of Internal Fixation's 3.5-mm dynamic compression plate (DCP) applied in a noncompression fashion (**Fig. 1**). More recently, contoured low-profile locking plates have become available, increasing its ease of application and the application in functional quadruped patients with a distal radius fracture (**Fig. 2**).[8]

INDICATIONS AND CONTRAINDICATIONS

The relative indication for a dorsal spanning bridge plate fixation of a distal radial fracture includes any patient with a distal radius fracture who is a functional quadruped requiring full weight bearing on the injured extremity in order to ambulate with an assistive device. In these patients, the goal is immediate unrestricted weight bearing; thus, any distal radius fracture is indicated. Additional treatment options specific to the use of a dorsal spanning bridge plate include complex articular fractures and/or fractures with significant metadiaphyseal comminution or bone loss.[7,8] Contraindications include patients with large open dorsal wounds that would result in exposed hardware.

TECHNIQUE

Either a small-fragment 3.5-mm locking DCP or a commercially available precontoured locking distal radius bridge plate can be used (**Fig. 3**). The authors' preference is the latter, as they are lower in profile, easier to place, and allow for the use of smaller screws. Metacarpal fixation with

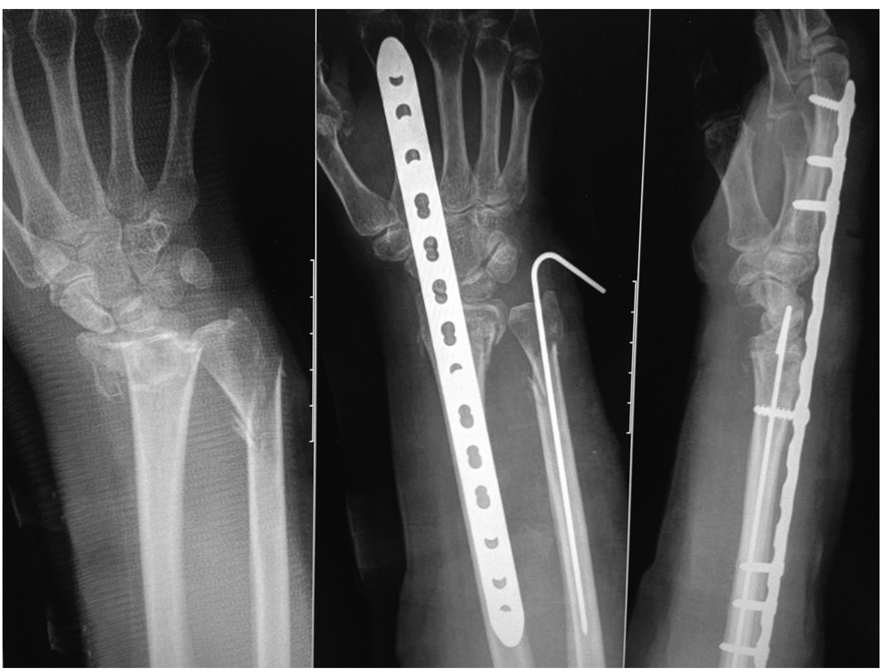

Fig. 1. A high-energy comminuted distal radius and ulna fracture in a polytrauma patient with an ipsilateral tibial plateau fracture and contralateral patella fracture, with interval dorsal spanning bridge plate application using a locking DCP, allowing immediate weight-bearing of the injured upper extremity on crutches.

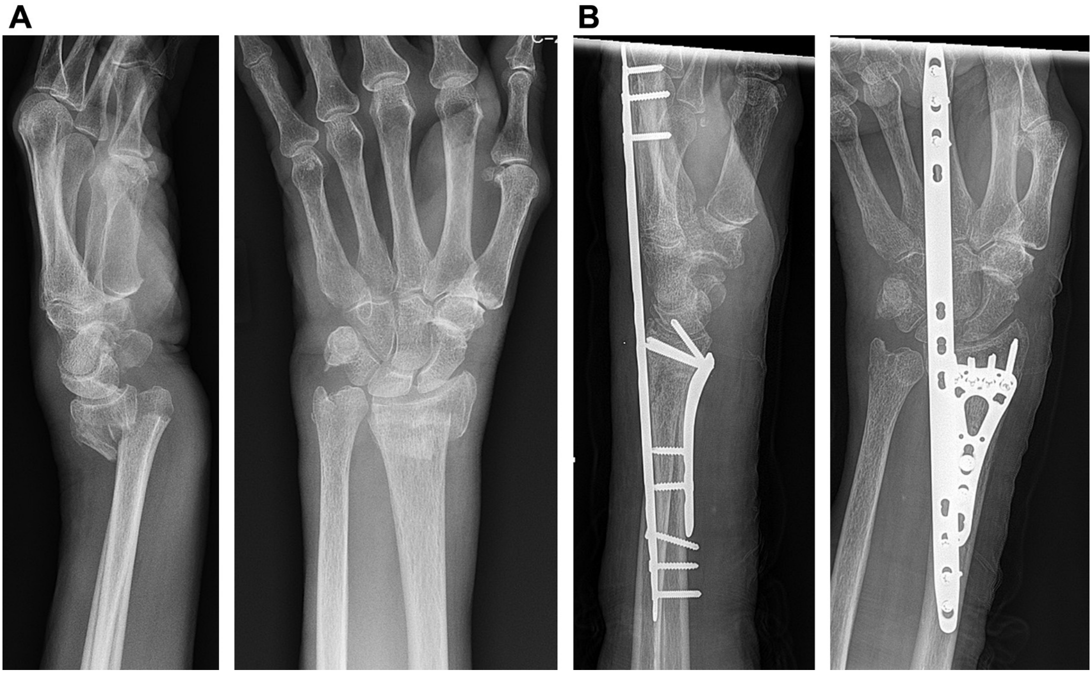

Fig. 2. (*A1, A2*) A low-energy fragility fracture of the distal radius in a walker-dependent patient who lives alone. (*B1, B2*) A dorsal spanning bridge plate was applied using a low-profile 2.7-mm locking dorsal spanning bridge plate, allowing immediate weight bearing with the injured upper extremity on the walker.

3.5-mm screws may be too large, and a screw diameter of 2.7 mm or smaller is preferable.

Patients are positioned supine with the injured arm extended onto a hand table. Either general and/or regional anesthesia can be used. The authors routinely use a tourniquet, but its application is optional. Intraoperative fluoroscopy is necessary. The fracture should be manipulated, and acceptable closed reduction of the distal radius is confirmed with fluoroscopy. If necessary, Kirschner wires (K wires) or a freer can be introduced percutaneously to help aid in fracture reduction, with the ultimate goal being to maintain the fracture reduction with ligamentotaxis once internally fixed. Two incisions are marked out with the plate applied to the dorsal hand and wrist (see Fig. 3). Note that the distal incision is placed between the second and third metacarpals allowing for the option to apply the plate to either index or middle metacarpal. The authors' preference is to apply the plate to the index metacarpal, thereby fixing the wrist in slight ulnar deviation to help facilitate weight bearing with an assistive device.

Fig. 3. A low-profile 2.7-mm locking dorsal spanning bridge plate (Depuy Synthes, West Chester, PA) applied to the dorsum of the injured wrist with the incisions marked for exposure and screw placement.

The first incision is placed for the metacarpal fixation. Blunt dissection is taken down to the selected metacarpal. The extensor tendons are mobilized and retracted (Fig. 4). The metacarpal is exposed; a freer is introduced to create a path under the second or third compartments, for either plate fixation on the index or middle metacarpals, respectively (Fig. 5). The bridge plate is then slid retrograde under the selected compartment (Fig. 6). Attention is paid to confirm that the plate is placed under and not over the extensor tendons. Fluoroscopy is then used to confirm the appropriate provisional placement of the bridge plate. Once satisfied, the second incision is placed proximally with blunt dissection down to the radial

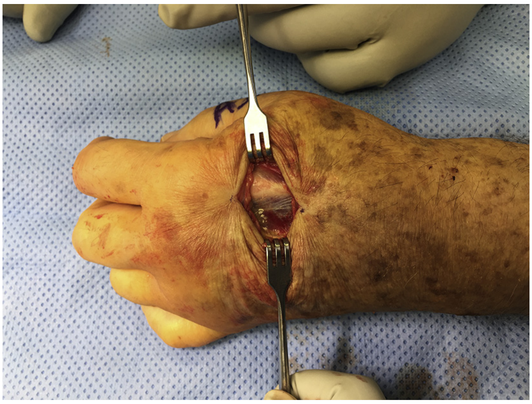

Fig. 4. With the extensor tendons retracted, the metacarpal is exposed.

shaft. If the plate is appropriately positioned, it will be found proximally between the extensor carpi radialis brevis and extensor pollicis longus tendons (Fig. 7).

The goal of internal fixation is 3 to 4 bicortical screws both proximally and distally, preferably with at least half being locking screws to increase the construct rigidity. Internal fixation begins with the placement of a nonlocking cortical screw distally in the metacarpal shaft first (Fig. 8). When the fracture is confirmed to be reduced with ligamentotaxis, a second nonlocking cortical screw is placed in the radial shaft proximally second (Fig. 9). Once satisfied with the fracture reduction and plate placement, the remaining screw holes are filled with locking screws (Fig. 10). Again, if the index metacarpal and the second compartment were selected for plate placement, the wrist will be fixed in slight ulnar deviation once the plate is internally fixed.

Following fixation, the skin incisions are closed in the standard fashion and a soft dressing is applied. Immediate weight bearing is allowed

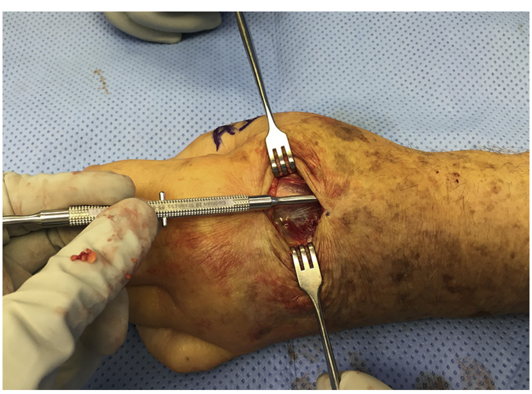

Fig. 5. A freer elevator is used to create a path under the extensor compartment in a retrograde fashion.

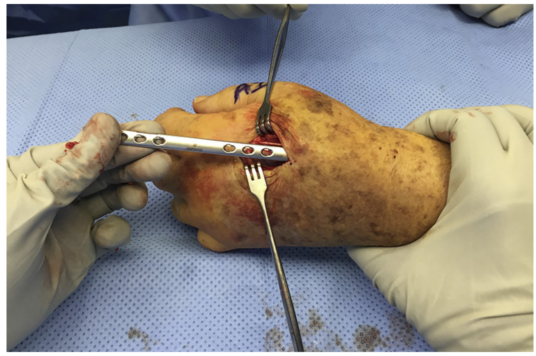

Fig. 6. The plate is inserted retrograde along the path created by the freer.

and encouraged. Staged removal of the bridge plate is planned for 8 to 12 weeks later, once satisfied with the fracture union.

CASE SERIES

The authors had a series of 11 patients with a minimum follow-up of 1 year (range 12–27 months) treated with a dorsal spanning bridge plate who were all functional quadrupeds requiring immediate weight bearing with an assistive device. All cases were low-energy injuries consisting of falling from standing. The authors' average patient age was 72 years old (range 64–87 years). Fractures classified using the AO system yielded 1 A2, 3 A3, 2 C1, 2 C2, and 3 C3 patterns. All surgeries were performed under general anesthesia without infection or reoperation, except for the planned staged removal of hardware. However, before the planned removal of the hardware, there were 2 cases of implant fracture at the middle plate holes corresponding to the wrist joint, which were assumed to be from fatigue failure (Fig. 11). These cases were taken back for removal of the

Fig. 7. Proximal exposure of the plate on the radial shaft should be directed between the interval of the extensor carpi radialis brevis and the extensor pollicis longus tendons.

Fig. 8. Fixation begins distally with placement of a nonlocking cortical screw in the metacarpal shaft.

Fig. 9. Fixation continues proximally next with placement of a second nonlocking cortical screw in the radial shaft. Note the assistant applying gentle traction across the wrist to further reduce the distal radius fracture with ligamentotaxis.

Fig. 10. Once satisfied with fracture reduction and plate fixation with a preliminary nonlocking cortical screw proximally and distally, the remaining plate holes are filled with locking screws to increase construct strength.

hardware earlier than planned, at approximately 8 weeks after their index surgery. For the remaining 9 cases, planned staged removal of the hardware was performed at 11 weeks on average (range 10–12). There were no cases of nonunion, tendon rupture, nerve injury or neuropraxia, or additional returns to the operating room beyond the planned staged of hardware removal.

DISCUSSION

In the authors' experience, treating patients with a distal radius fracture who are now functional quadrupeds with dorsal spanning plate fixation is a viable treatment option to improve or restore mobility with assistive devices. Intraoperatively, the treatment is straightforward, with the application of the plate requiring 2 small incisions and limited dissection, thereby limiting operative morbidity. Postoperatively, immediate weight bearing with the injured limb is allowed. Based on the authors' series, they now use low-profile

Fig. 11. Fatigue failure of the plate through the middle screw holes of the plate on the (*A*) anteroposterior and (*B*) lateral radiographs.

precontoured locking plates without midplate holes to avoid future fatigue fractures (Fig. 12).

In a prospective study by Ruch and colleagues,[9] 22 patients with comminuted distal radius fractures were treated with a dorsal spanning bridge plate and followed for at least 1 year, with an average age of 54 years (range 24–93 years). They included patients with high-energy distal

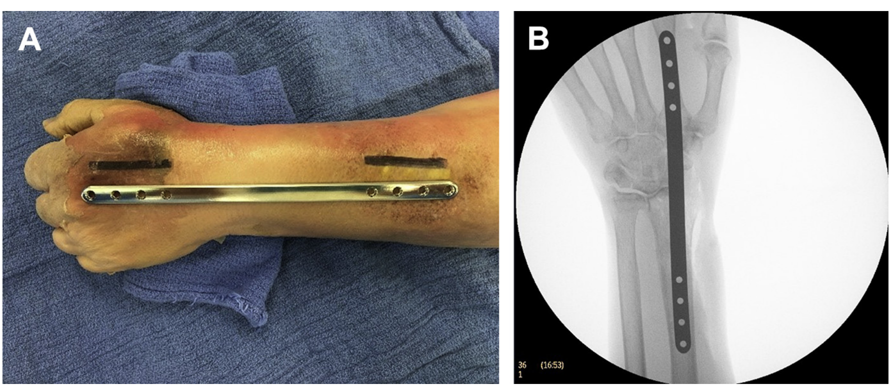

Fig. 12. (*A*) A low-profile 2.5-mm locking dorsal spanning bridge plate without holes in the middle of the plate to avoid fatigue failure of the plate with repetitive loading with weight bearing. (*B*) In situ, the lack of holes in the central portion are illustrated on fluoroscopy.

radius fractures with at least 4 cm of proximal diaphyseal extension. Patients were seen immediately postoperatively as well as at 6 months and 1 year postoperatively, with 18 patients also available at 2 years postoperatively. Nine of these patients had open fractures, with 2 requiring flap coverage. Postoperatively, patients were allowed to perform activities of daily living and had a 5-lb lifting restriction. Patients who had lower extremity injuries were allowed platform weight bearing only. In this series, all fractures healed with a mean time to hardware removal of 124 days. They reported no tendon ruptures and no cases of hardware failure. Although they had 3 infections, all were in patients with open fractures. They found no patients with digital stiffness; however, 3 patients had a 15 extensor lag while the plate was in place, which resolved after plate removal. When comparing this with the authors' patient cohort, it should be noted that these patients all had high-energy trauma, whereas in the authors' series, all patients had low-energy trauma with immediate full weight bearing allowed with the bridged upper extremity.

Richard and colleagues[11] performed a retrospective review of 33 patients older than 60 years with comminuted distal radius fractures treated with distraction plating. This study used a dorsal approach with a 2.5-mm or 3.5-mm DCP spanning plate. In 7 of these patients, supplemental K-wire fixation was also used. Patients were splinted postoperatively until suture removal and were given a 2-kg lifting restriction while the plate was in place. Patients were allowed to bear weight through the forearm if an assistive device was needed. The plates were removed at a mean of 119 days. All fractures healed, and there were no cases of tendon rupture. Ten patients developed digital stiffness, with one requiring tenolysis at the time of plate removal. In addition, there was one infection in a patient who had an open fracture during the initial injury. Patients were able to obtain a functional range of motion of the wrist with a mean flexion of 46° and mean extension of 50°; however, this was not compared with a control group or to the contralateral wrist.

Despite the advantage of immediate weight-bearing ability and consistent fracture healing using a dorsal spanning bridge plate for distal radius fractures, there are some disadvantages to this treatment algorithm. First, patients with a traditionally nonoperative fracture pattern would be undergoing a surgical procedure and are subject to the risks associated with surgery for plate placement and a second surgery for plate removal.

Second, as with any hardware, the plate and screws are subject to hardware failure or soft tissue irritation. In the authors' experience, they have also experienced plate fracture due to fatigue failure from repetitive loading and weight bearing. Fortunately, a plate fracture typically occurred 8 weeks after the index surgery when the fracture was already healed, thereby not altering postoperative weight-bearing allowance. However, based on this experience, the authors now preferentially use a 2.5-mm low-profile precontoured dorsal spanning bridge plate that does not have holes in the midsection of the plate to avoid fatigue fracture of the plate (see Fig. 12).

Third, stiffness of the wrist and fingers are of concern with prolonged immobilization of the wrist in neutral. In the authors' series, all patients underwent a gentle manipulation under anesthesia at their staged second surgery for removal of the plate and no patients required additional surgeries, including no interventions for loss of wrist motion. A previous meta-analysis and a later a prospective randomized trial comparing spanning external fixation with plate fixation confirm the authors' finding and also demonstrated no significant difference in wrist range of motion at 1 year.[12,13]

SUMMARY

Functional quadrupeds are patients who rely on their hands for weight bearing with an assistive device, such as walker-dependent patients and polytrauma patients. Dorsal spanning bridge plate fixation of distal radius fractures in functional quadrupeds is an effective surgical treatment option to facilitate immediate weight bearing through the injured wrist. This treatment benefits patients by allowing them earlier mobility and independence with their assistive devices. In the authors' series, patients have had satisfactory results. Further study is needed to assess the functional end points and patient satisfaction comparatively after dorsal spanning bridge plate fixation relative to other nonspanning fixation options as well as nonoperatively treated distal radius fractures in this patient population.

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