Bilateral Comminuted Radial Shaft Fractures From a Single Gunshot: Fixation With Alternative Techniques

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Abstract

Acute bilateral radial shaft fractures are an unusual entity that has not been previously reported in the literature. Given its bilaterality, this rare clinical entity is best treated with stable internal fixation.

Here we report the case of an 18-year-old right-hand–dominant man who sustained a low-caliber gunshot injury. He had been driving with both hands on the steering wheel when he was struck by a single bullet. The bullet caused displaced fractures of the left proximal radial shaft and the right distal radial shaft. Each fracture had extension outside the mid-diaphysis. The patient underwent operative fixation with plating of the right upper extremity and intramedullary nailing on the left side. Both fractures healed, and range of motion was functional.

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There are multiple options for fixation of diaphyseal radial shaft fractures. The standard of care, rigid plating with 3.5-mm dynamic compression plates, has proved to be effective for the central diaphysis of the radial shaft.[1] However, when fractures involve the diaphyses and the proximal or distal metaphyseal regions, novel fixation techniques are needed. In addition, in fractures with severe comminution, restoration of radial bow and length is imperative even when compression plating is not possible.

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Here we present the case of a patient who sustained a single gunshot that caused bilateral radial shaft fractures. These fractures extended into the proximal third of the radius on one side and distally into the metaphyseal-articular region on the other side. The patient was treated with 2 different techniques and implants, both of which yielded relative stability and an acceptable clinical result. We obtained this patient's written informed consent to report his case in print and electronically.

Case Report

Our patient was an 18-year-old right-hand–dominant man who sustained a low-caliber gunshot injury. He had

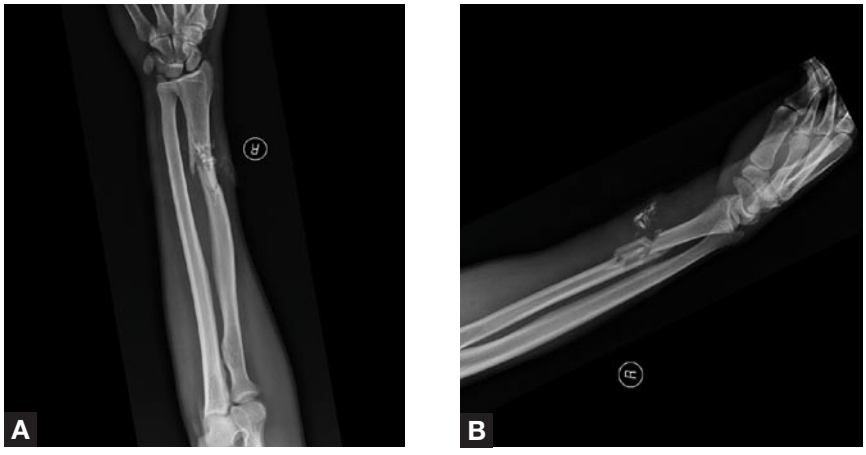

Figure 1. Anteroposterior (A) and lateral (B) radiographs of right forearm show comminuted fracture of distal third of radius. Anteroposterior radiograph shows fracture extending into radial metaphysis.

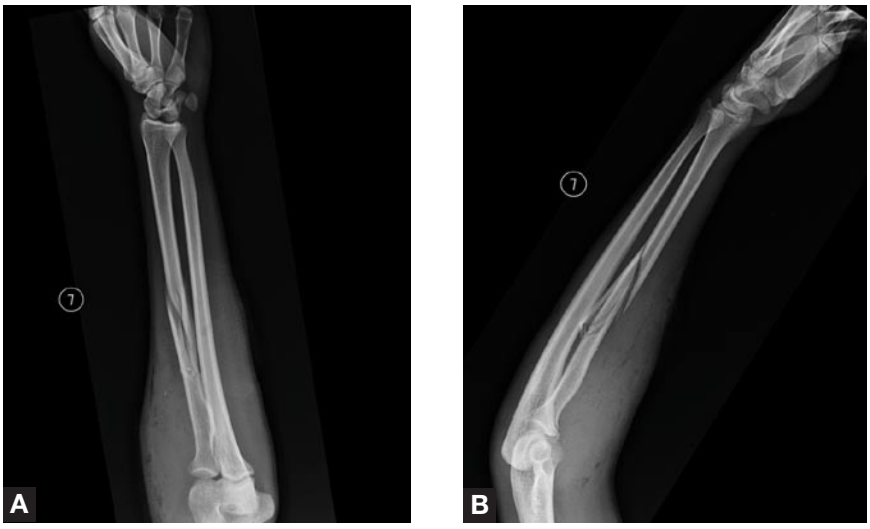

Figure 2. Anteroposterior (A) and lateral (B) radiographs of left forearm show comminuted fracture of proximal third of radius. The fracture has an unstable pattern with a large butterfly fragment that appears to be split longitudinally.

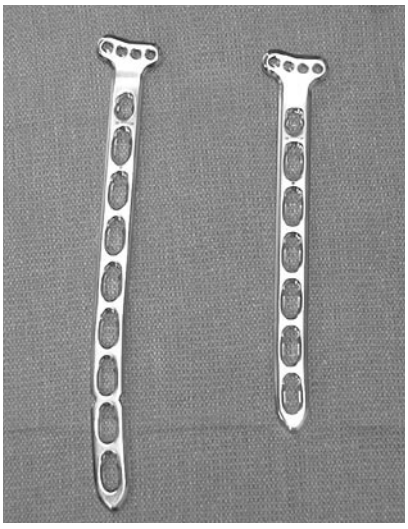

Figure 3. Hybrid plates designed for fixation in radial shaft proximally and metaphysis distally. Screws holes are locking distally and are "combi" type proximally, which accept locking or nonlocking screws. Seven-hole plate (right) is straight; 9-hole plate (left) has bow to accommodate radius.

been driving with both hands on the steering wheel (one in the 10 o'clock position, the other in the 2 o'clock position) when he was struck by a single bullet. The bullet entered the dorsal surface of the proximal third of the left forearm, exited the volar surface, and then entered the volar surface in the midaspect of the right forearm before exiting more distally on the dorsal aspect. The bullet caused fractures of the left proximal and right distal radial shafts.

On evaluation, there were 4 small soft-tissue wounds: 1 entrance and 1 exit on the left upper extremity and 1 entrance and 1 exit on the right side. Bilaterally, the elbows and wrists had good passive range of motion (ROM) that was limited only by pain. No instability of the elbow or distal radioulnar joints was detected. The patient was neurologically intact in all motor and sensory distributions distal to the injuries. The digits were well perfused with palpable radial and ulnar pulses.

Radiographs showed a comminuted fracture of the distal third of the radius on the right (Figure 1) and a long spiral-oblique fracture with a large butterfly fragment in the proximal third of the radial shaft on the left (Figure 2). Close examination of the radiographs of the right wrist revealed that a single fracture line extended from the level of the comminution to the metaphysis of the distal radius as a sagittal split. Radiographs of the left radius showed extension of the fracture to approximately 1 cm distal to the bicipital tuberosity.

The patient was taken to the operating room for simultaneous fixation of the radii by 2 surgical teams. The right radial shaft fracture was stabilized with a specialized locking plate designed for distal metadiaphyseal fractures (Figure 3). With use of an extended volar Henry approach, the right radius was exposed. The radius was reduced and fixed with a bridge plating technique spanning the area of comminution (Figure 4). Care was taken to restore the radial bow and to ensure that the proximal and distal radioulnar joints were reduced and stable.

The left proximal radius was treated with retrograde intramedullary nail fixation. This technique was chosen because of the comminution of the fracture and the expected difficulty of the proximal exposure. A dorsal

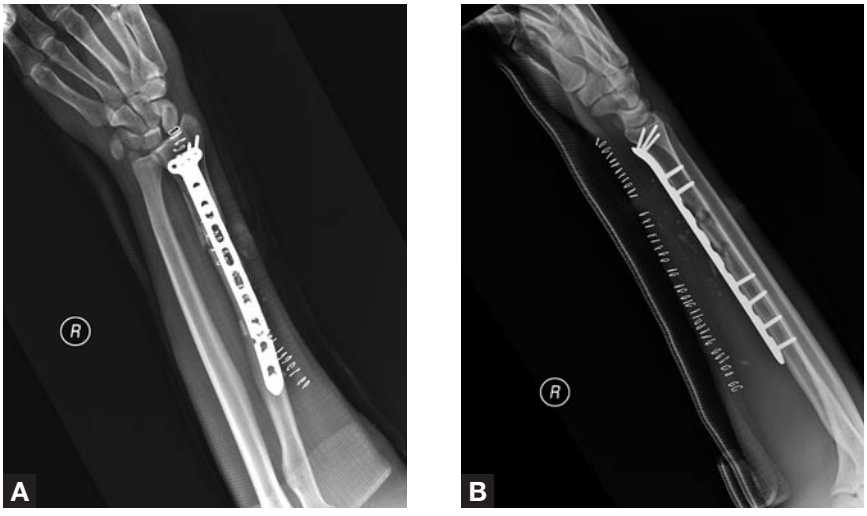

Figure 4. Anteroposterior (A) and lateral (B) radiographs of right forearm after fixation with hybrid volar plate. Four nonlocking diaphyseal screws are placed proximally and a combination of locking and nonlocking screws distally.

Figure 5. Anteroposterior (A) and lateral (B) radiographs of left forearm after fixation with retrograde intramedullary nail. Nail was impacted proximally into subchondral bone of radial head and locked distally with screw.

approach through the third dorsal compartment was used to visualize Lister's tubercle distally for the insertion portal. The proximal locking screws were not inserted secondary to the desire not to open the fracture site and the fear of injury to the posterior-interosseous nerve. The nail was impacted into the subchondral bone of the radial neck and head and had multiple points of shaft contact along its course. Again, care was taken to reestablish the radial bow and length and to ensure that the proximal and distal radial ulnar joints were congruently reduced and stable (Figure 5).

After surgery, the patient was limited to light (<2 1b) lifting with the bilateral upper extremities for 4 weeks. The right upper extremity was maintained in a soft dressing with no restriction on ROM. The left forearm was maintained in a sugar-tong splint for 3 weeks to allow early fracture consolidation before motion. In this splint, the patient was permitted a limited arc of flexion and extension at the elbow but was not allowed pronation or supination. At 3 weeks, a removable splint was applied, and active motion was allowed. Formal occupational therapy was instituted to promote ROM, progressive strengthening, and activities of daily living.

At the most recent follow-up, approximately 5 months after surgery, the patient was evaluated radiographically and clinically. Radiographs showed healing of both fractures with acceptable alignment (Figure 6). Clinical examination demonstrated right upper extremity ROM to be 80° pronation, 70° supination, elbow extension to 5°, and elbow flexion to 140° and left upper extremity ROM to be 70° pronation, 55° supination, elbow extension to 5°, and elbow flexion to 140° (Figure 7). The patient had minimal tenderness in the forearm and was neurovascularly intact.

Discussion

Common mechanisms of injury for forearm shaft fractures include motor vehicle accidents, falls, direct trauma, athletic injuries, and gunshot wounds. Significant disability with limitations

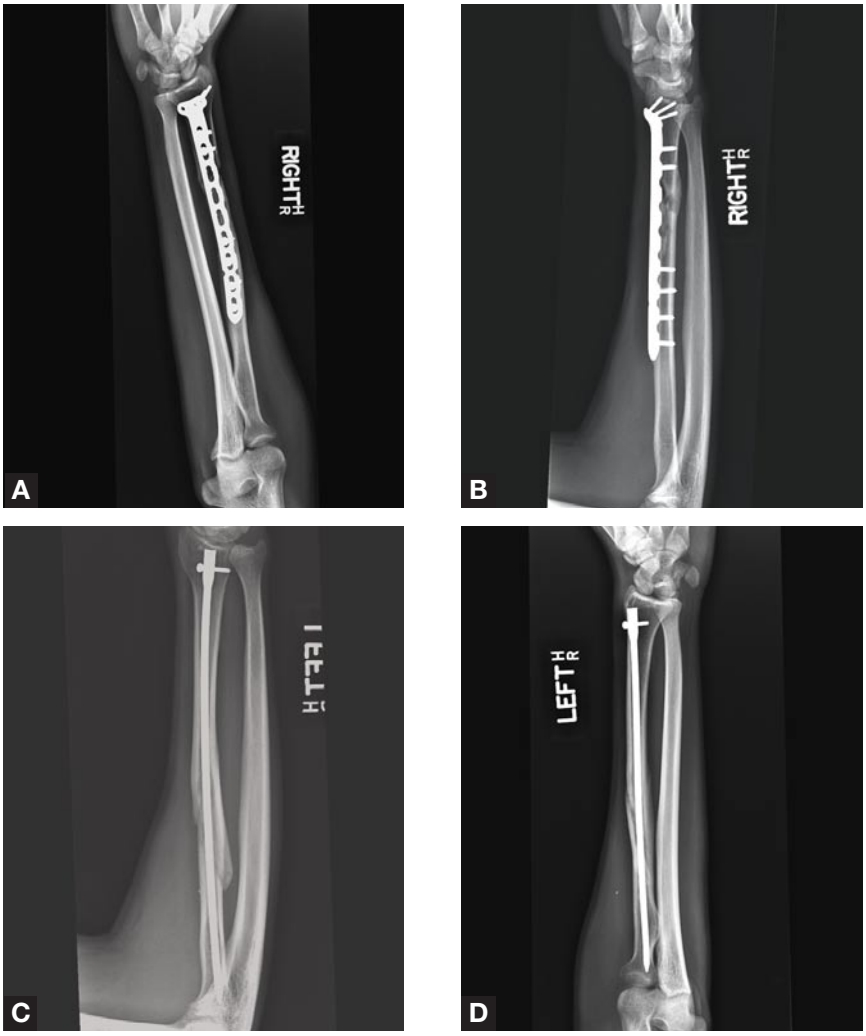

Figure 6. Anteroposterior and lateral radiographs of right (A, B) and left (C, D) forearms 5 months after surgery show fractures healed in good alignment and with restoration of bow of radial shaft.

Figure 7. Functional supination (A) and pronation (B) at clinical follow-up. Incisions are well healed and have a cosmetically acceptable result.

in forearm rotation and hand function can result after improper treatment of these injuries.[2,3] Anatomical realignment with stable fixation is important in restoring proper function of the forearm axis.[4] The bilaterality of the case described in this article increases the need for stable fixation and a good functional result. Bilateral stress fractures of the radial shaft have been reported in the literature,[5] but, surprisingly, operative treatment of bilateral acute radial shaft fractures has not been previously reported.

The gold standard of treatment for diaphyseal shaft fractures is compression plating using 3.5-mm implants with union rates of more than 92%.[1,6,7] However, when the fracture has extension proximally or distally into the metaphyses or articular surface, different fixation techniques may be needed.

Malrotation, angular deformities, and radial bow deformity significantly affect ROM, strength, and functional outcomes. Schemitsch and Richards[8] evaluated 55 adults with both-bone forearm fractures treated with plating. At a mean follow-up of 6 years, they found that good functional results, grip strength, and forearm rotation were correlated with restoration of the amount and location of the radial bow relative to the contralateral side. Restoring radial and ulnar length is also important in restoring functional elbow and wrist ROM.

With severe comminution, as occurs in gunshot wounds, bridge plating with restoration of mechanical axis and rotation is more advisable than extensively stripping soft tissue and reapproximating each fragment.[9] Bridge plating is preferably done with a limited contact standard plate or locking plate. Decreasing plate–bone contact and possible periosteal devascularization preserves more of the bone's blood supply and allows for improved healing and decreased nonunion risk. Gardner and colleagues[10] found locking compression plates to be biomechanically similar to, if not having subtly increased mechanical superiority to, standard plating of the radial shaft.

With these longer bridge plates, all the screw holes need not be filled. In a biomechanical study, Sanders and colleagues[11] found that plate length was more important than number of plate screws in contributing to the bending strength of the construct. Longer plates with 2 screws on either side of the fracture ("near-near/far-far") were more effective than shorter plates with every screw hole filled. This principle is important in comminuted fractures, as in gunshot wounds, in which good bony purchase is not possible at the fracture site. Previously, 6 to 8 cortices on either side of the fracture have been suggested as appropriate fixation when plating. Should the specialized plate used in our patient's case not be available, a standard T-plate and a 3.5-mm dynamic compression plate may be stacked together, as described by Mudgal and Ring.[12]

With severe comminution, acute bone grafting can be considered. However, there is evidence that, with appropriate stabilization and soft-tissue–preserving techniques, bone grafting may not increase union rates significantly.[13,14] The fracture mechanism of a gunshot wound, as in our patient's case, also seems to allow healing without supplementary bone grafting.

Intramedullary nailing has also been suggested as an alternative treatment method for diaphyseal radial fractures. With extensive comminution, intramedullary nailing of the fracture may decrease the local surgical trauma to the soft tissues while still restoring length and rotation of the extremity. Interlocking nails make rotational control possible, but locking at the far end of the nail may not be necessary. Impaction of the pointed distal tip of the nail near the subchondral bone may allow for adequate interference fit, as was accomplished in our patient's case. It is imperative to template the contralateral extremity so nail contour will match the anatomical dorsoradial bow of the radius to preserve pronation and supination. Investigators have reported union rates (94%-100%) and time to union (means of 10 weeks with closed nailing and 15 weeks with open nailing) comparable to those of open reduction with plating.[15-17]

"...Sanders and colleagues[11] found that plate length was more important than number of plate screws in contributing to the bending strength [of bridge plates]."

Conclusions

We have reported a case of bilateral radial shaft fractures from a single bullet, in which one side was treated with a specialized metadiaphyseal plate and the other with a retrograde intramedullary nail. Standard plating remains the gold standard for most such cases, but intramedullary fixation and specialized hybrid plating that restores proper bony anatomy may be indicated in some situations. Our patient's bilateral injuries healed uneventfully, and the clinical result was acceptable.

Authors' Disclosure Statement

Dr Capo wishes to note that he is a consultant to and has received research support from Synthes Corporation. The other authors report no actual or potential conflict of interest in relation to this article.

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