

1 **Abstract**

2           We report a case of a 29-year-old man who presented with a distal humeral shaft fracture  
3 sustained by blunt trauma. Physical examination and nerve conduction study were consistent  
4 with injury to the median and radial nerves proximal to the elbow. The patient underwent open  
5 reduction and internal fixation of the humeral shaft fracture with neurolysis of the median and  
6 radial nerves. Repeat electromyography at 6 months postoperatively showed recruitment of  
7 motor units in all muscles sampled, in keeping with clinical improvement. At 16 months follow-  
8 up, the patient was full strength in all muscle groups, was back to all activities with no  
9 restrictions, and was discharged from follow-up. Our case describes clinical improvement after  
10 surgical intervention in a patient with combined median and radial nerve palsies following distal  
11 humeral shaft fracture.

12 **Keywords:** Humeral shaft fracture, Holstein-Lewis fracture, radial nerve, median nerve, nerve  
13 palsy, electromyography, nerve conduction study

14 **Introduction**

15           Humeral shaft fractures usually occur in young adults after high-energy trauma and in the  
16 elderly following low-energy trauma. They account for approximately 5% of all fractures and  
17 represent the third most common type of long bone fracture (1). The annual incidence of humeral  
18 shaft fractures has been estimated to be between 10 and 14.5 per 100,000 individuals (2, 3).  
19 While fractures of the mid-diaphysis are most common, fractures of the distal third of the  
20 humerus carry the highest risk for radial nerve injury, especially in fractures that are significantly  
21 displaced or comminuted (1). A systematic review of radial nerve palsy following humeral shaft  
22 fracture found that the overall prevalence was approximately 11.8% of all cases (4). Spiral  
23 fractures of the distal humerus, known as Holstein-Lewis fractures, carry a risk of acute radial  
24 nerve palsy in up to 22% of patients (5). The most common clinical presentation of radial nerve  
25 injury is wrist drop (6), although patients frequently also experience an inability to extend the  
26 thumb and fingers at the metacarpophalangeal joints (7). Sensory deficits in radial nerve injuries  
27 at this level include the radial aspect of dorsum of the hand and wrist (8).

28           Humeral shaft fractures presenting with median nerve injury are rare, but can occur in  
29 open fractures or those associated with brachial plexus injury (1). Rohilla *et al.* presented a case  
30 of combined radial and median nerve palsies after humeral shaft fracture, treated operatively,  
31 with subsequent neurologic recovery (9). We present here a case of combined radial and median  
32 nerve palsies after a distal humeral shaft fracture.

33

34 **Case Presentation**

35 *History and Examination.* A healthy 29-year-old man was evaluated in our upper  
36 extremity clinic approximately two weeks after sustaining a closed humeral shaft fracture from a  
37 physical altercation. The patient was initially managed nonoperatively in a coaptation splint  
38 before transition to a functional brace at one week follow-up. Electromyography and nerve  
39 conduction study was obtained 11 days after injury due to concern for nerve injury and showed  
40 severe axonal injury to the median and radial nerves proximal to the elbow. Given the atypical  
41 neurologic deficits in this patient, he was referred to the hand and upper extremity clinic.

42 On examination, the skin was intact and the patient had a normal vascular exam. On  
43 sensory exam, he had decreased sensation in the median and radial nerve distributions in his  
44 hand. On motor exam, he had no motor function of wrist extensors, extensor pollicis longus  
45 (EPL), extensor digitorum communis (EDC), and flexor pollicis longus (FPL). He had trace  
46 motor function only of flexor digitorum superficialis (FDS) and flexor digitorum profundus  
47 (FDP) of the index finger. Motor function of FDP of the long, ring, and small fingers was intact.  
48 Motor function of the flexor carpi ulnaris (FCU) and dorsal interossei was intact.

49  
50 *Imaging Studies.* Plain films of the left humerus demonstrated a comminuted, displaced,  
51 and angulated fracture of the distal humeral shaft (Figure 1). After reduction and application of  
52 coaptation splint, plain films demonstrated improved alignment (Figure 2).

53  
54 *Surgical Treatment.* Three weeks after injury, due to intolerance of conservative therapy,  
55 the patient was taken for open reduction and internal fixation of the humeral shaft fracture with  
56 neurolysis of the median and radial nerves. The humerus was approached by a standard

57 anterolateral approach. The radial nerve was found to be encased in a thick sheath of scar distally  
58 and draped over the fracture as it exited the spiral groove; however, at no point in its course was  
59 it entrapped in the fracture. The radial nerve appeared contused but in continuity; it was  
60 decompressed throughout the zone of injury. The median nerve was also found to be encased in a  
61 thick sheath of scar. While contused, the median nerve was in continuity and also decompressed  
62 throughout the zone of injury. The fracture was fixed with lag screws and locking neutralization  
63 plate.

64

65 *Postoperative Course.* The procedure was complicated by an infected hematoma one  
66 week postoperatively requiring irrigation and debridement with hardware retention, with  
67 resolution after a prolonged course of antibiotics. Home occupational therapy was initiated  
68 starting 2 weeks postoperatively. At 6 weeks postoperatively from the index surgery, the patient  
69 regained trace motor function of his wrist extensors. At 12 weeks postoperatively from the index  
70 surgery, the patient regained 4/5 strength in wrist extension. Trace FPL activity returned at 18  
71 weeks postoperatively, and trace EDC activity returned at 20 weeks postoperatively. At 6 months  
72 follow-up, the patient had regained clinical function in all affected muscle groups, including  
73 wrist extensors, EPL, EDC, FPL, FDS, and FDP. Repeat electromyography at 6 months  
74 postoperatively showed recruitment of motor units in all muscles sampled, in accordance with  
75 his clinical improvement. Plain films at 6 months postoperatively showed fracture healing with  
76 no hardware complications (Figure 3). At 16 months follow-up, the patient was full strength in  
77 all muscle groups, was back to all activities with no restrictions, and was discharged from  
78 follow-up.

79 **Discussion**

80 We have presented a rare case of combined median and radial nerve palsies in a patient  
81 with a closed distal humeral shaft fracture. Given the close anatomical relationship between the  
82 posterior diaphysis of the humerus and the radial nerve, which traverses approximately 6.5  
83 centimeters in the spiral groove, radial nerve injuries occur in 11.8% of all humeral shaft  
84 fractures and in up to 22% of spiral fractures of the distal third of the humerus (1, 4, 5, 10). In  
85 fractures of the middle third of the humerus, radial nerve injuries are likely a result of the  
86 proximity of the nerve to the bone; however, the association between radial nerve injuries and  
87 distal humeral shaft fractures is more likely a function of the fracture pattern and energy of  
88 trauma through the bone (6). Since the radial nerve is separated from the distal humeral shaft by  
89 up to 5 cm of muscle, comminution or displacement of the intermuscular septum by fracture  
90 fragment displacement endangers the nerve (7). It is thought that the radial nerve is tethered at  
91 the level of the distal humerus where it pierces through the intermuscular septum and is therefore  
92 at risk from traction injury from fracture displacement. This mechanism is likely what  
93 contributed to the palsies noted in our patient.

94 Management of distal third humeral shaft fractures remains controversial, and often  
95 involves balancing the risks of wound complications and radial nerve injury with operative  
96 treatment against malalignment and inability to tolerate immobilization with nonoperative  
97 treatment (11). Median and ulnar palsies after humeral shaft fracture are rare, and are usually  
98 only seen in cases of open fractures, significant muscle damage, and total or partial brachial  
99 plexus injury (1). There have only been two case reports of humeral shaft fractures resulting in  
100 isolated median nerve palsy (11, 12). Apergis *et al.* reported a case of a 19-year-old man who  
101 sustained a closed humeral shaft fracture and an ipsilateral nondisplaced distal radius fracture

102 after motorcycle accident who developed acute median nerve palsy (12). He showed clinical  
103 evidence of anterior interosseous nerve dysfunction, exhibiting weakness of his FPL and FDP of  
104 the index finger. Electromyography, however, demonstrated denervation of all muscles  
105 innervated by the median nerve. There were no sensory deficits. The patient was managed  
106 conservatively and achieved union by 8 weeks, with neurologic improvement at 12 weeks and  
107 full recovery at 20 weeks post-injury. Macnicol described a case of a 10-year-old girl who  
108 sustained a greenstick fracture of her humeral shaft after a mechanical fall and developed median  
109 nerve entrapment.<sup>8</sup> She did not exhibit any immediate neurologic sequelae, however she  
110 complained of difficulty moving her hand one week after casting. After conservative  
111 management resulted in fracture healing, five months after initial injury, the patient displayed  
112 thenar wasting, hypoesthesia of the palmar aspect of the index, long, and radial half of the ring  
113 fingers, and total paralysis of all muscles innervated by the median nerve except for the FDP to  
114 the index and long fingers. Surgical exploration of the median nerve two years after the acute  
115 injury revealed entrapment of the nerve in the humerus with neuroma formation. Excision of  
116 neuroma, neurolysis of the median nerve, and multiple tendon transfers were performed.

117         There has been one case of combined radial and median nerve injury in a humeral shaft  
118 fracture previously reported by Rohilla *et al* (9). The patient sustained a transverse humeral shaft  
119 fracture at the junction of the middle and distal thirds secondary to a motor vehicle collision. The  
120 patient was treated surgically and had complete neurologic recovery after 12 weeks. We report a  
121 rare case of combined radial and median nerve injuries, including both sensory and motor  
122 deficits in both distributions, after distal humeral shaft fracture. Our patient sustained a  
123 comminuted fracture of the distal humerus, and developed electrical study confirmed severe  
124 axonal injury of both nerves. Our decision to transition the patient from conservative to operative

125 management was a result of intolerance of nonoperative treatment after three weeks of  
126 conservative therapy.

127         Our case represents a unique combination of injuries to two nerves following humeral  
128 shaft fracture. Due to the rarity of this presentation, the preferred treatment algorithm for this  
129 condition is unclear. For isolated, closed, non-penetrating radial nerve injuries associated with  
130 humerus fractures, the literature supports conservative management with functional bracing (13,  
131 14). Sonneveld *et al.* reported that early surgical exploration revealed undamaged radial nerves  
132 in 13 of 14 patients, and that delayed exploration did not adversely affect motor recovery in  
133 cases where spontaneous recovery did not occur (14). A more recent study of patients with  
134 complete sensory and motor radial nerve palsy following closed humeral shaft fracture found  
135 that the mean time to spontaneous recovery of the radial nerve was 12 weeks after fracture (13).  
136 Median nerve injuries associated with humerus fractures are rare, and no preferred treatment  
137 algorithm exists. Both reported cases of isolated median nerve injury after humerus fracture were  
138 treated conservatively, one with neurologic recovery and the other complicated by nerve  
139 entrapment and neuroma development (12, 14). Our case describes clinical improvement after  
140 surgical intervention in a patient with combined median and radial nerve palsies following distal  
141 humeral shaft fracture.

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180

181 **Figure Legends**

182 **Figure 1. AP plain film of the humerus at initial presentation.** Injury plain film of the left  
183 humerus demonstrates a comminuted, displaced, and angulated distal humeral shaft fracture.

184

185 **Figure 2. AP (A) and lateral (B) plain films of the humerus three days after reduction in a**  
186 **coaptation splint.** Plain films of the left humerus demonstrate interval reduction of the distal  
187 humeral shaft fracture with improved alignment.

188

189 **Figure 3. AP (A) and lateral (B) plain films of the humerus six months postoperatively.**  
190 Plain films of the left humerus demonstrate interval healing of the distal humeral shaft fracture  
191 with no evidence of hardware complications.

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