Fractures of the Humerus with Radial-Nerve Paralysis*

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In our experience when paralysis of the radial nerve complicates fracture of the shaft of the humerus, a specific situation usually exists. The fracture is in the distal third of the humerus; it is spiral in type, the distal bone fragment is displaced proximally with its proximal end deviated radialward, the radial nerve is caught in the fracture site, and, if there is a comminuted fragment, the nerve surface of the distal end of the proximal fragment that damages the nerve. If fractures in this area occur and the initial trauma does not produce gross displacement of the type described, then radial-nerve paralysis may not occur (Fig. 1).

HUMERUS

LATERAL INTERMUSCULAR SEPTUM

RADIAL NERVE

RADIUS

Rt. Ant. View

A. B.

**Fig. 1**

Drawing showing relationship of nerve to fracture before (left) and after displacement. With radial displacement and overriding of the distal fragment, the nerve, fixed to the fragment by the intermuscular septum, is trapped between the fracture surfaces.

To understand the mechanics of this fracture syndrome, the following empirical factors are pertinent.

As Whitson demonstrated, contrary to the descriptions in standard anatomical textbooks, the radial nerve does not travel along the so-called spiral groove.*

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Radial-Nerve Complication

The radial nerve complication exists. The fracture at the proximal bone fragment is radialward, the radial fragment, it is the relatively small size of the bone that damages the nerve and does not produce gross deformity. The injury may not occur.

Fig. 2

Lateral and anteroposterior roentgenograms show typical fracture. Note characteristic location in the distal one-third, its spiral contour, and the radial deviation of the end of the distal fragment.

Seven typical fractures were collected, four treated by us and three seen in consultation for the United States Navy (A.II.). In an effort to determine the frequency of this particular syndrome, 341 consecutive fractures of the shaft of the humerus at one private hospital were also reviewed. Of these, 193 were in the proximal third of the shaft of the humerus, sixty-three in the mid-portion of the humerus, and eighty-five in the distal portion of the humerus. Of this whole group, six had associated radial-nerve involvement, an incidence of 1.8 per cent. Five of the six displaced fractures of the type we are describing. The other was a fracture in the middle third of the humerus. This case is presented here merely to illustrate that this fracture differs from the syndrome we are describing (Case 8). The low incidence of radial-nerve involvement in this series is of interest in view of the recent report by the Pennsylvania Orthopedic Society, in which radial-nerve involvement...
was found in 12 per cent of a large series of mid-shaft humeral fractures.

Case Presentations

Case 1. A. P., a woman fifty years old, was thrown against the side of the car in an automobile accident and experienced sudden severe pain in the right arm. On admission, a diagnosis of fracture of the humerus with radial-nerve paralysis was made.

At operation, the distal fragment of the humerus had impaled the radial nerve on its tip at the point where the nerve passes from the posterior compartment, through the interosseous septum, into the anterior compartment (Fig. 2). The nerve was freed from the bone fragment, displaced laterally to this distal fragment. The fracture was reduced and fixed with two screws placed transversely across the fracture line. A palm-to-axilla plaster cast was applied. The patient was discharged from the hospital, the patient transferred to another area for follow-up care. Further information is available.

![Fig. 3](image)

Case 2. Failure to achieve proper alignment and contact of the fracture surfaces by manipulation suggests interposition of the radial nerve and related soft tissues.

Case 2. G. W., a man, thirty-six years old, was injured when his car struck a tree. He had immediate pain in his left arm above the elbow, marked pain in the left part of his chest and pain in the right shoulder area. The admitting diagnoses were open comminuted fracture of the distal end of the left humerus with radial-nerve paresis; fractures of the second through the eighth ribs on the right; and comminuted fractures of the third through eighth ribs on the left with a full chest and a fractured right scapula.

Initially, there was only slight restriction of extension of the fingers at the metacarpophalangeal joints and of the wrist on the left with diffuse hyposthesia to light touch throughout the hand, especially on its dorsoradial aspect. Since the chest injury took precedence, at first débridement of the wound in the arm was done with immobilization of the humeral fracture with a palm-to-axilla plaster cast. Recheck of the finger-wrist movements less than twenty-four hours after injury showed complete loss of dorsiflexion of both the wrist and the fingers.

At operation fifteen days after the injury the proximal portion of the radial nerve was traced carefully into the distal part of the arm. The nerve was completely enmeshed in the fibrous tissue around the fracture. The nerve was in continuity; and, after being dissected free from the fibrous tissue bed, it was displaced laterally and the fracture of the humerus was reduced and fixed by means of a plate and four screws.

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cases of the factors to note here was the failure to obtain apposition of the fragments after initial reduction and immobilization in a plaster cast (Fig. 3). This should have suggested that the fragments were not united between the fragments as was also the situation in Case 5. Three months after operation activity of the extensor carpi was returned and five months after operation full finger power was noted. Full return of powerful finger and wrist motion was noted at eight months. Return of hand at one year was slight hypoplasia in the anatomical snuff box.

Case 3. M.W., a woman, fifty years old, fell in her bathtub, landing on her left arm. She had immediate pain and gross deformity of the left arm, but remained at home for twenty-four hours. At that time examination revealed a spiral fracture of the shaft of the distal part of the humerus with complete paralysis of motor and sensory components of the radial nerve. At a forty-eight hours after the injury, the distal humeral fragment was immediately visible at the proximal end of the wound. The tip of this fragment had pierced the muscle and come out of the muscle. The fracture was resting between the ends of bone at the point where it would normally have pierced the lateral seantum. The nerve was removed from its position between the two ends of the fracture and was placed radially. The fracture was then reduced and held by two screws. Return of muscle function in the fingers and wrist five months after surgery, with hypoplasia in the anatomical snuff box and a tingling sensation in the same area.

Case 4. L.W., a man, thirty-three years old, was working on a scaffold on a bridge when twenty feet, sustaining an open comminuted fracture of the left humerus with complete nerve paralysis. He also fractured his right clavicle. Initially the wound was debrided and a plaster cast was applied. The wound became infected and drained. Exploration of the site was delayed for three months. It was found that the nerve was severed and displaced to the medial side of the humeral fragment, where it was bound down in marked scar tissue. The nerve ends were not divided and repaired by end-to-end suture after cutting back the nerve ends to satisfactory length. This repair was done under moderate tension. Return of some dorsiflexion power of the wrist and sensation was first noted seven months after the nerve repair.

Case 5. C.G. (U.S.N.), a man, twenty years old, broke his left arm while playing football. He was transferred to a hospital. On admission there was barely demonstrable weakness of wrist and abduction on the left side. There was hypoplasia in the distribution of the radial nerve. The fracture of the humerus was manipulated and held in a plaster sugar-tong splint. During the next days, while the arm was immobilized in this splint, the radial-nerve weakness gradually cleared and numbness in the region of the anatomical snuff box in the left hand developed. Operation revealed the radial nerve was traced upward and found, with a portion of muscle, to pass through the proximal portion of the fracture cleft. The nerve was freed up to the point of passage through the intermuscular septum, then the hole through this was enlarged to nerve slide-free. The interposed tissue was removed from the fracture site, and the fracture site was united anatomically and held by means of two screws and a plaster cast.

Case 6. C.K. (U.S.N.), a man, twenty-three years old, while working aboard a tug, sustained a comminuted fracture of the distal third of the shaft of the humerus when he fell into the water (Fig. 4). Wrist-drop was noted on admission to the hospital on the day of the accident. Electrolyte wire was placed through the olecranon, and the arm was then placed in balanced Electromyographic studies done six days later showed no activity in motor units supplied by the radial nerve. The ninth day after the injury the fracture in the distal part of the right humerus was united and the radial nerve was found to be continuous over a distance of about one and one-half inches at the level of the fracture site but to be grossly intact. Injecting sterile saline solution in the nerve revealed the neurilemmal sheath to be intact. Accordingly the nerve was removed from the fracture site, and the fracture was reduced and held with two screws. Muscle tissue was placed between the radial nerve and the fracture site. An axilla-to-palm plaster cast was applied and the wound closed.

Case 7. W.B. (U.S.N.), a boy eighteen years old, in air-automobile accident, sustained a bone and joint surgery.

* Bone and Joint Surgery *
comminuted fracture of the shaft of the right humerus in the distal third with complete loss of radial-nerve function, an open comminuted fracture of the left tibia, and a closed fracture of the right lateral malleolus. Initially a plaster splint was used for the fractured humerus. This was changed to a hanging plaster cast. Roentgenograms then revealed that the bone ends were in contact. There was no return of radial-nerve function during the first four weeks after fracture.

At operation twenty-nine days after injury, the nerve was found to be approximately 25 per cent severed at the fracture site with only a thin tenuous strand connecting the two ends. The nerve ends were trapped in the fibrous callus at the fracture site. The ends of the nerve were freshened and approximated with 000000 silk sutures.

The fracture was immobilized in a plaster cast. One month later the patient fell with recurrence of pain at the fracture site, but no change in position of the fracture. Continued immobilization resulted in bone union. When the patient was last seen, there had been no return of nerve function. No follow-up was possible.

**Fig. 4**

Comminuted fracture with the third fragment displaced medially and the distal fragment in the characteristic position with overriding and radial deviation of its proximal end.

**Fig. 5**

Of 341 fractures of the humeral shaft this was the only fracture not in the distal one-third which was associated with paresis of the radial nerve.

**Fig. 6**

Fixation of a simple spiral fracture with two screws after removal of the nerve from the fracture site.

**Case 8.** T. McI., a boy fifteen years old, sustained a spiral fracture in the middle one-third of the humerus with injury to the radial nerve causing loss of sensation on the dorsum of the hand between the first and second metacarpals but no muscle weakness (Fig. 5). A hanging cast was applied. On the following day, it was noted that the patient was unable to extend the thumb and the fingers fully at the metacarpophalangeal joints. On the tenth day following injury, with no additional treatment, there was evidence of return of radial-nerve function. The patient could again extend the thumb and fingers, and sensation had returned. There was no return of radial-nerve function during immobilization in the plaster cast.

This case is mentioned merely to illustrate what is not meant by the syndrome under consideration. Among 341 humeral fractures this was the only one not in the distal one-third which was associated with injury to the radial nerve.
with complete lack of movement of the distal fragment of the humerus. This was one of the cases in which dislocation occurred in the two-part fracture. The patient fell with no violence; continued observation revealed no return of function of the nerve. In the case of the fracture, there are certain factors which do not vary. The fracture is always in the distal one-third of the humerus; it is spiral with radial displacement at the fracture site and overriding of the distal fragment; and there is involvement of the radial nerve, both sensory and motor components. The only part of the syndrome that varies is the degree of involvement of the nerve; this involves a spectrum from confusion to complete severance. The degree of trauma must be clearly violent, and there must be definite displacement of the fragments of the humerus as a result of the injury if nerve damage is to occur.

In a number of these fractures, an initial closed reduction was attempted; in a more profound radial-nerve paralysis resulted. Roentgenograms, made after

![Fig. 6](image1)

![Fig. 7](image2)

Fig. 6 - Full and three-quarter views of a fracture with a plate and four screws. Here comminution made secure screw fixation impossible, revealed that the fragments were being held apart presumably by interposed soft tissue. All the fractures were eventually treated surgically, and the interposed soft tissue was invariably found to include the radial nerve, to the extent that the nerve was surrounded by early callus between the ends.

On the basis of our experience, we strongly advise against attempted closed reduction of fractures of the distal one-third of the humerus with demonstrable radial-nerve paresis. We recommend primary open reduction through an anterolateral approach. The nerve should be located, dissected free, and displaced laterally by the distal fragment. The fracture should then be reduced; and, because of its character, it can usually be satisfactorily fixed by two screws placed across the fracture. When there is sufficient comminution to make simple screw fixation not satisfactory, a light bone plate with four screws can be used. A very light, palm-to-
axilla hanging plaster cast is used for external immobilization (Figs. 6 and 7). The optimum time for nerve repair, the best method for repairing the radial nerve, and the treatment of permanent weakness of the wrist and finger extensors are not the concern of this paper. We wish only to emphasize that the radial nerve is frequently caught between the fracture surfaces in this readily recognized fracture and is likely to be damaged either at the time of injury or during treatment.

Summary

This paper presents seven cases illustrating a humeral-fracture syndrome complicated by radial-nerve paralysis. The fracture occurs in the distal third of the humerus at a point where the radial nerve comes through the lateral intermuscular septum and is in contact with the bone. Due to the force of the injury, the proximal fragment is displaced distally, carrying with it the intermuscular septum and the radial nerve contained within its foramen in the septum. At the same time the tip of the distal fragment is moved proximally and radially, lacerating or trapping the radial nerve between the bone fragments. Primary open reduction is the treatment of choice for this injury. Closed manipulation is contraindicated when the criteria of the syndrome are present.

References


DISCUSSION

Dr. Bland W. Cannon, Memphis, Tennessee: Discussion of this presentation by a neurological surgeon necessitates the assumption that the method of treatment of fractures of the humerus, with radial-nerve impairment, depends on the integrity of the nerve. We accept this compliment, for we know that you, as orthopedists, are aware of singularities of nerve which allows a favorable result ultimately, regardless of the method of treatment.

Fortunately, the usual sequelae of traumatic neuritis and other painful syndromes in injury are escaped because of the insignificant sensory component of the radial nerve. Repair of this lacerated or divided nerve usually yields return of function to all muscles of its denervation. Not infrequently, near normal neurological status is obtained.

The crucial anatomical location for radial-nerve injury in fracture of the humerus, as Holstein and Dr. Lewis have designated. However, the decision to elect prompt open repair should not be based on the existence of nerve paralysis. If severance of the nerve has occurred, the immediate post-injury period is not the optimum time for nerve repair. If confusion, vascular laceration, is found on inspection of the nerve, only limited constructive information has been gained. A lapse of time is almost necessary in evaluating the functioning status of the nerve, application of our neurophysiological or electrodiagnostic aids, such as electromyography, is usually impractical during the two weeks immediately following this type of traumatic paralysis. The significant exception to our advised delay is illustrated by two of Dr. Holstein’s cases, in which a more profound paralysis followed closed reduction.

If you produce or increase paralysis by manipulation, proceeding with surgical intervention and decompression of the nerve is wise.

Of the three cases depicting severance of the nerve, the lapse of fifteen days, twenty days, and three months, respectively, before surgical attack probably improved the chance for successful nerve repair and neurological recovery.

A delay in nerve repair of approximately fifteen days facilitates a more accurate determination of the area of viable nerve in the confused and damaged proximal and distal stumps. In a suitable bed for protection of the sutured nerve can be assured. Such factors are of prime importance in obtaining the best results. Otherwise, evidence favors the assumption that

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