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Case Report

Posterior interosseous nerve palsy after closed proximal forearm fractures

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ABSTRACT

Although rare, posterior interosseous nerve (PIN) palsy can occur in patients with a closed proximal forearm fracture and may present in a delayed fashion after initial trauma.

In this case series, three cases of posterior interosseous nerve (PIN) injury following proximal forearm fractures are presented and discussed.

Our literature search yielded six studies concerning PIN injury in radial head/neck fractures and proximal forearm fractures. Out of a total of 8 patients, 7 patients were treated non-operatively and in one patient a PIN release was performed. One patient was lost to follow-up, all other 7 patients showed successful recovery.

A treatment algorithm for PIN palsy after proximal forearm fractures is provided. Based on our experience and what we found in literature, it seems safe to treat PIN palsies conservatively.

Introduction

The radial nerve divides into its superficial branch and the posterior interosseous nerve (PIN), also known as the deep branch of the radial nerve, at the level of the radiocapitellar joint. Muscles innervated by the PIN include the extensor carpi radialis brevis, supinator, extensor carpi ulnaris, extensor digitorum communis, extensor digiti quinti, extensor indicis proprius, abductor pollicis longus and the extensor pollicis longus and brevis. The extensor carpi radialis brevis is in some cases innervated by the superficial branch of the radial nerve or the radial nerve so that its function may be preserved in patients with a PIN injury [1,2]. The extensor carpi radialis longus is typically innervated by the proper radial nerve. Therefore, the typical clinical presentation of PIN palsy comprises of limitations in finger and thumb extension together with radial deviation upon wrist extension due to preserved extensor carpi radialis longus and sometimes brevis function. As the PIN does not provide cutaneous innervation, there will be no sensory nerve loss upon physical examination.

Due to its close proximity to the radial head and proximal shaft of the radius, the vulnerability of the PIN during surgical exposure of the proximal radius is well appreciated [1,2]. However, studies describing PIN injury following proximal forearm fractures are sparse.

The purpose of this paper is to describe the development of PIN palsy occurring after radial head fracture. Moreover, we will provide a review of the current literature and provide treatment recommendations.

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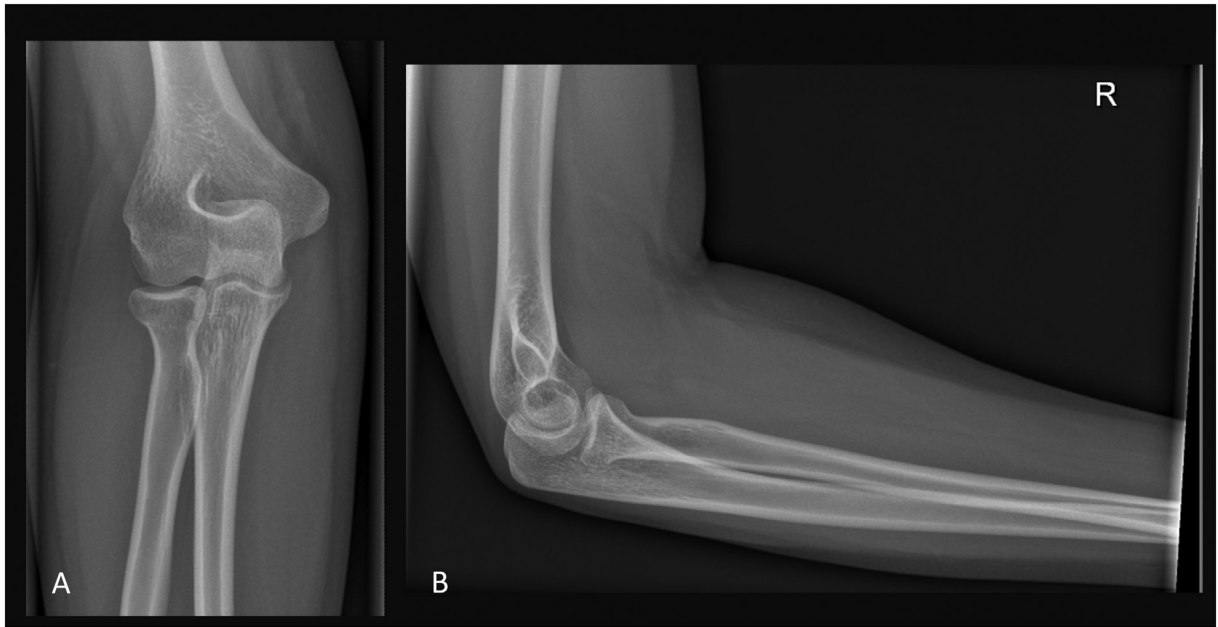


Fig. 1. AP (A) and lateral (B) elbow and forearm x-ray of patient 1, showing a non-displaced radial neck fracture.

Case series

Patient 1

A 23-year-old, right hand dominant, female patient presented at our emergency department with a painful elbow after slipping on the ice and falling on her right elbow. She had no relevant previous history. Physical examination showed tenderness over the radial head as well as the distal radius and ulna. Active or passive motion of the elbow was not possible due to pain. Flexion and extension of the fingers was painful and limited, as was dorsal flexion of the wrist. There was no loss of sensibility or signs of vascular injury. X-rays of the right elbow, wrist and hand showed a radial neck fracture (Judet type I, Fig. 1). Because there was no displacement of the fracture, the patient was treated with a compression bandage for a total of 5 weeks. One week following trauma she was seen at the outpatient clinic where persistent inability to extend the fingers was noted despite adequate pain control (Supplemental video). This indicated a palsy of the posterior interosseous nerve. Five weeks after initial presentation she was still unable to actively extend digit 1–3. Wrist extension was possible but with radial deviation. Standard EMG testing of the median, ulnar and radial nerve showed no abnormal results.

She was referred to our hand therapists and function improved over time. Nine weeks after the accident she was able to extend digit 1–3 actively again, although power hadn't fully recovered yet. One year after injury she reported full recovery.

Patient 2

Our second patient is a 17-year-old female patient, otherwise healthy, presented with a painful left elbow after a fall with gymnastics. Physical examination showed swelling of the left elbow and tenderness over the medial epicondyle, radial head and distal humerus. Elbow flexion and extension was limited. No signs of neurovascular injury of the upper extremity were noted.

X-ray and CT scan of the left upper extremity showed a displaced radial neck fracture (Fig. 2). The fracture was surgically reduced and fixated using two headless compression screws followed by two weeks cast immobilization (Fig. 3). Two weeks after surgery the patient presented at the clinic with loss of finger extension and thumb abduction. The cast was replaced by a Cock-Up splint and she was referred to the neurologist. At presentation at the neurology department, 10 weeks after surgery, her EDC function was already recovering with a Medical Research Council (MRC) grade 2–3. Upon the following clinic visits, finger extension improved and was returned to normal 7 months after surgery.

Patient 3

A 16-year-old boy presented at our emergency department with a painful and swollen right arm. He fell at the swimming pool and his right arm got stuck in the ladder of the pool.

Physical examination showed swelling of the proximal forearm, dorsum of the hand and fingers. He was able to extend his fingers. Sensibility and vascularization of the right hand were unaffected. X-rays showed a dislocated proximal forearm fracture (Fig. 4). He

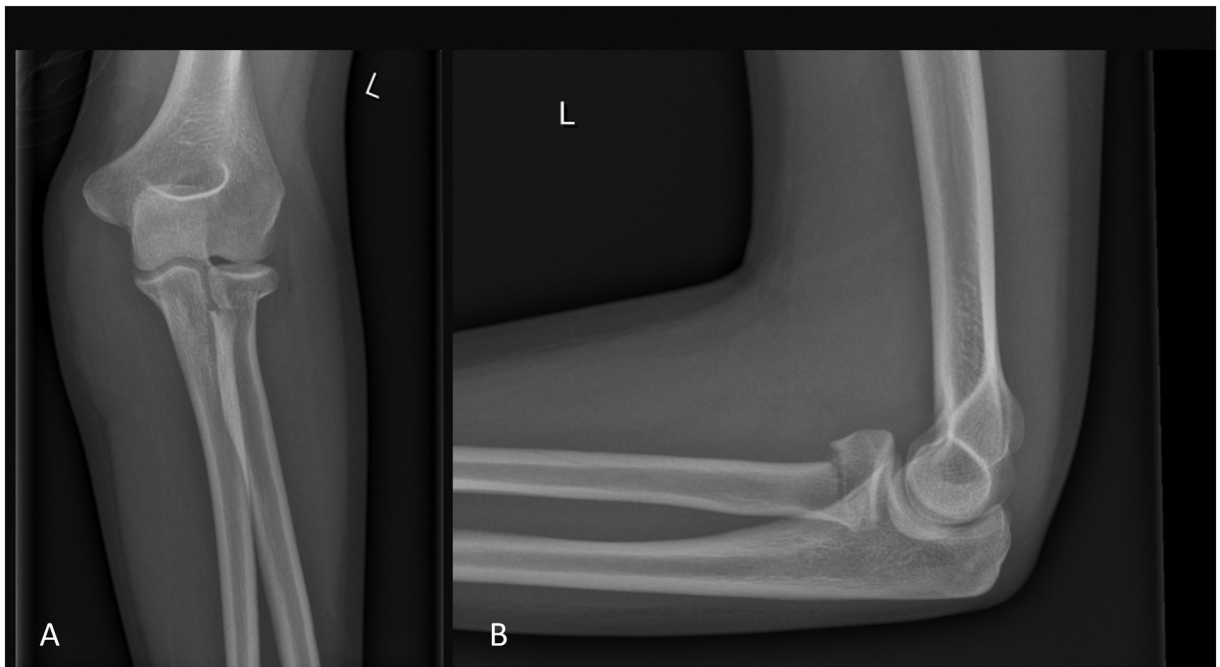


Fig. 2. AP (A) and lateral (B) elbow and forearm x-ray of patient 2, showing a radial neck fracture.

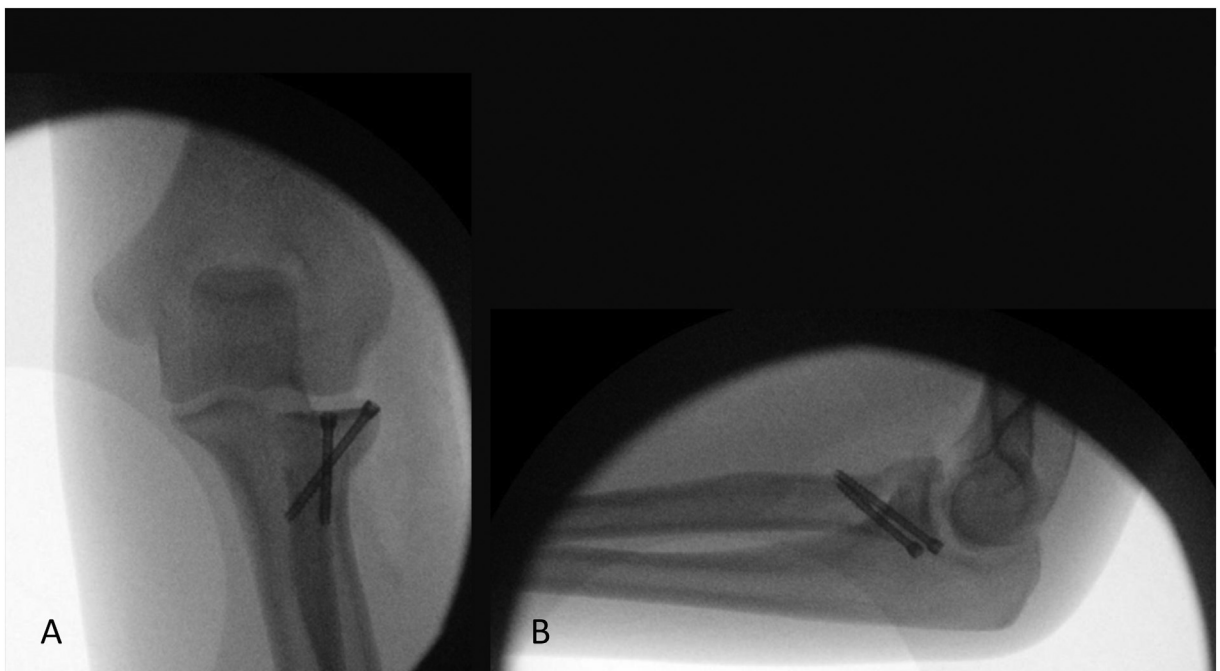


Fig. 3. Intraoperative imaging of patient 2 after ORIF for a radial neck fracture.

was initially planned for surgery within one week, but returned to the emergency department that night because he was no longer able to actively extend digit 1–5. Wrist extension was intact without a noticeable radial deviation. Traumatic PIN injury was suspected. An open reduction and plate fixation of the fracture was performed (Fig. 5). During surgery the PIN was not explored. A Cock-up splint was fitted and hand therapy started shortly after surgery.

Six weeks after surgery EDC function and thumb extension were both MRC grade 2. EMG six weeks following trauma showed severe axonal compromise of the PIN between the branch to the EDC and EIP. No signs of EIP reinnervation were seen. Hand therapy was continued and six months after trauma complete recovery of wrist and finger extension was established.



Fig. 4. AP (A) and lateral (B) forearm x-ray of patient 3, showing a dislocated proximal antebrachial fracture.

Discussion

Despite the suspected vulnerability of the PIN in proximal forearm trauma, due to its close proximity to the radial head and proximal shaft of the radius, studies describing PIN injury following proximal forearm fractures are sparse. We presented three cases of closed proximal forearm fractures that presented with concomitant PIN injury.

Vulnerability of the PIN at the level of the elbow has been appreciated during surgical exposure of the elbow or proximal radius [1,2]. Naturally, traumas at this level such as radial head or neck fractures or fractures of the proximal shaft of the radius also carry



Fig. 5. Intraoperative imaging of patient 3 after ORIF for an antebrachial fracture.

the risk of PIN injury. However, only few cases of PIN injury after fractures of the radial head or neck have been described (Table 1) [3–7]. Of these five reported cases, the PIN injury was treated non-operatively in four and in only one case PIN release was performed. One patient was lost to follow-up and outcomes are unknown. All other four patients reported complete recovery after various follow-up (range 2 days–6 months) [3–7].

Only one study described PIN palsy in relation to proximal forearm fractures. Hirachi et al. [8] describe three patients with a proximal forearm fracture. All patients were treated non-operatively and regained MRC 4–5 motor function.

The etiology of PIN palsy in fractures with a non- or minimally displaced radial head has not been fully clarified. Possible theories include PIN compression by edematous surrounding tissue or fracture hematoma, direct damage from a fractured radius fragment and iatrogenic damage during closed reduction [3–7].

Careful physical examination of hand and wrist function is key. At first presentation the patient may be too painful for reliable assessment of PIN function. It is recommended to test motor function at each follow-up visit. As appreciated in our cases, as well as in previous literature, it is not uncommon for PIN palsy to occur several hours to days after the initial injury. Even when initial neurological examination is unremarkable, it is crucial to repeat careful physical examination. This way it can be determined whether the palsy is more likely to be due to initial trauma or iatrogenic after intervention such as open or closed reduction. In patient 2, clinical signs of PIN injury were noted two weeks after surgery while pre-operative function was unremarkable. In this case, iatrogenic injury to the PIN may have been induced during surgery by traumatic placement of a Hohmann retractor.

When the PIN palsy is diagnosed before operation, exploration of the nerve is not recommended due to the favorable natural course of this type of injury. For both traumatic and suspected iatrogenic injury initial steps are similar; start observation, provide the patient with a protective Cock-up splint and start hand therapy. The fracture should be treated as indicated and careful neurovascular examination performed at each follow-up visit. When there are no signs of spontaneous recovery after approximately 6 weeks of observation, EMG studies are indicated to determine severity of nerve injury and prognosis. Signs of neurapraxia or no abnormalities on EMG allow for longer observation because of the high potential for spontaneous recovery. However, when there are signs of axonotmesis or neurotmesis on EMG, plan further EMG follow-up to evaluate for later signs of recovery. Surgical exploration should be considered, especially when iatrogenic injury is suspected or when EMG follow-up over time and clinical presentation do not show any signs of recovery. For best functional outcome, reinnervation within 12–18 months should be aimed for [9,10].

Based on our experience and what we found in literature, it seems safe to treat PIN palsies conservatively. A treatment algorithm is provided in Fig. 6.

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.tcr.2019.100240>.

Ethical approval & informed consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Due to the retrospective nature of this study, formal consent was not required.

Table 1
Prior published reports of PIN injury in radial head/neck fractures.

	Sudhakar et al. [6]	Daurka et al. [3]	Serrano et al. [4]	Stepanovich et al. [5]	Terra et al. [7]
Patient sex	Male	Male	Male	Male	Male
Patient age at time of injury (years)	28	55	21	38	42
Relevant medical history at time of injury	Not reported	None	None	None	None
Description of the injury	Fracture left radial head (mason type 1)	Fracture right radial head (mason type 3)	Transverse fracture through the radial head with displacement of a small bone fragment	Minimally displaced radial neck fracture	Radial head fracture (mason type 4)
Description of palsy	Sensation hand and forearm intact. Good extension in index and little finger, poor extension in ring finger, no extension in middle finger.	Initially normal neurological examination. Returned 24 h after injury with loss of extension and supination at elbow joint. 36 h after injury there is wrist, finger and thumb drop. No sensory loss.	Initial normal motor function. Presents again 4 days after injury with limited wrist extension, not able to extend fingers and thumb. Normal sensation in hand and forearm, normal radial pulse.	Initial normal motor function. 1 day after initial presentation there is an inability to cross fingers, extend fingers and adduct the thumb. Intact sensation.	Upon presentation extension deficit at the level of the MCP joints, abduction and extension deficit of the thumb. Radial deviation with wrist extension.
EMG	-	EMG (36 h after injury): PIN palsy.	-	EMG (12 weeks after injury): axonal compromise of the PIN and mild ulnar nerve myelinopathy	-
Treatment	Non-operatively	Partial excision of radial head fragments. Open exploration of the PIN with complete release and neurolysis. PIN is reported to be oedematous but structurally intact.	Non-operatively	Non-operatively	ORIF of the displaced radial head with screw fixation. No exploration of the PIN
Reported outcome	Progressive recovery after 2 months.	Normal function after 6 weeks.	Unknown, patient was lost to follow-up.	At 6 months after injury there was a near-complete recovery with only a mild residual weakness of the EPL.	Normal PIN function two days after surgery.

Abbreviations: EMG: electromyography, PIN: posterior interosseous nerve, EPL: extensor pollicis longus, MCP: metacarpophalangeal, ORIF: open reduction internal fixation.

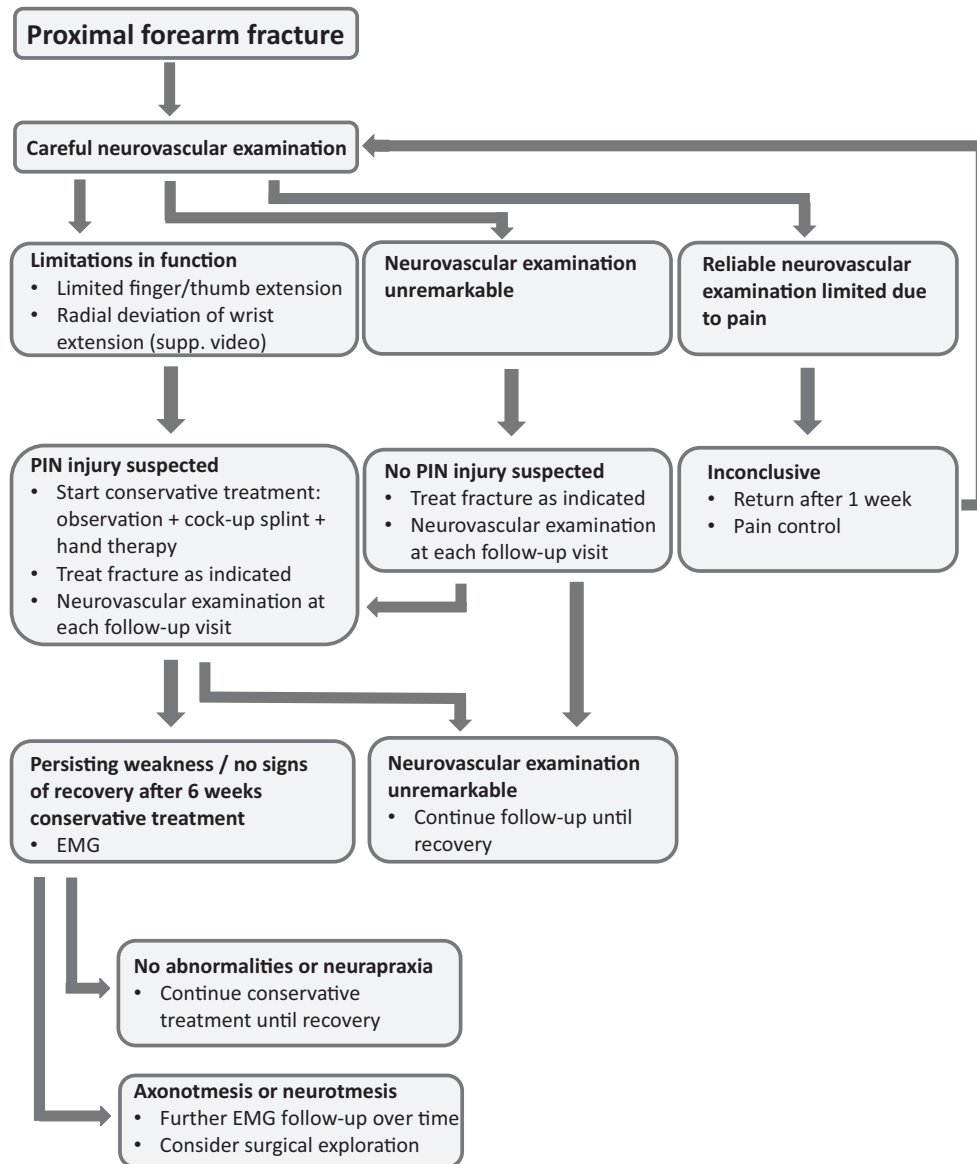


Fig. 6. Treatment algorithm for detection and treatment of PIN injury in proximal forearm fractures.

Declaration of competing interest

There are no financial disclosures and no conflicts of interest.

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