

# Persistent Posterior Interosseous Nerve Palsy Associated with a Chronic Type I Monteggia Fracture-Dislocation in a Child: A Case Report and Review of the Literature

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**Abstract** We present a rare case of persistent complete posterior interosseous nerve palsy associated with a chronic type I Monteggia elbow fracture-dislocation consisting of anterior dislocation of the radial head and malunion of the ulna in an 8-year-old child requiring surgical treatment. Posterior interosseous nerve neuropraxia following acute Monteggia injury patterns about the elbow has been described and is thought to be secondary to traction or direct trauma. The condition typically resolves following successful closed reduction of the radial head. This report describes combined treatment of the nerve and skeletal injury for the chronic type I Monteggia injury. The literature is reviewed, and diagnostic challenges with and treatment options for chronic Monteggia fracture-dislocations in children are discussed.

**Keywords** Pediatric · Monteggia fracture-dislocation · Radial head dislocation · Posterior interosseous nerve palsy · Elbow trauma

## Introduction

Chronic complete posterior interosseous nerve (PIN) palsy is a recognized but uncommon sequela of the type I Monteggia elbow fracture-dislocation in children. This report describes combined radial nerve exploration with PIN neurolysis and surgical reconstruction of a chronic type I Monteggia injury in a child. PIN subluxation followed by chronic compression at the proximal radioulnar joint (PRUJ), radiocapitellar joint (RCJ), and arcade of Froese may be suspected in this rare clinical scenario.

## Case Report

An 8-year-old right-hand-dominant boy presented to our institution approximately 3 months after sustaining an injury to his left elbow following a fall on ice. His elbow injury was initially treated at another institution with cast immobilization for 6 weeks. Following cast removal, the mother complained of persistent deformity of the left elbow and weakness of the hand. Radiographic evaluation revealed evidence of a chronic type I Monteggia fracture-dislocation with persistent anterior dislocation of the radial head and malunion of the ulna (Fig. 1). Clinical examination was consistent with a complete posterior interosseous nerve palsy. Digital and thumb extensions were graded 1/5, and there were no palpable contractions of the extensor carpi radialis brevis or extensor carpi ulnaris. Sensory examination in the radial nerve distribution was unremark-

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Investigation conducted at NYU Hospital for Joint Diseases, New York, NY

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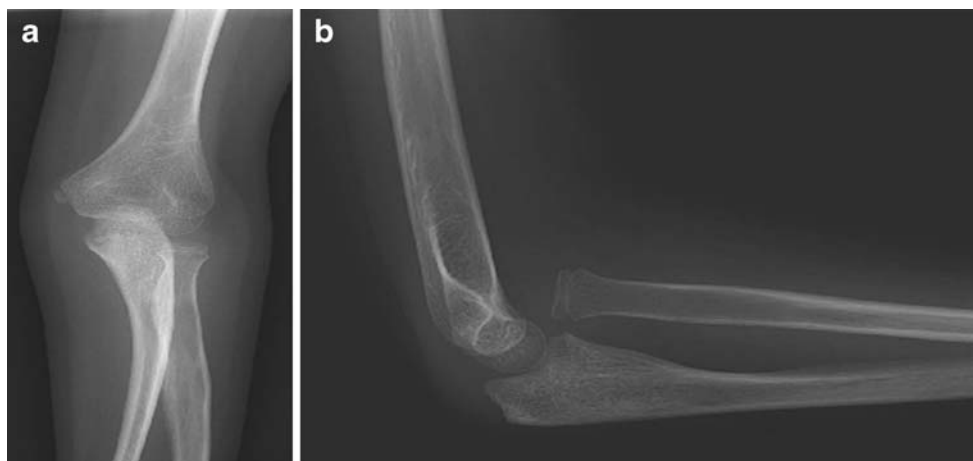
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**Fig. 1** Preoperative anteroposterior (a) and lateral (b) elbow radiographs demonstrate the chronic type I Monteggia fracture-dislocation with persistent anterior dislocation of the radial head and malunion of the ulna.



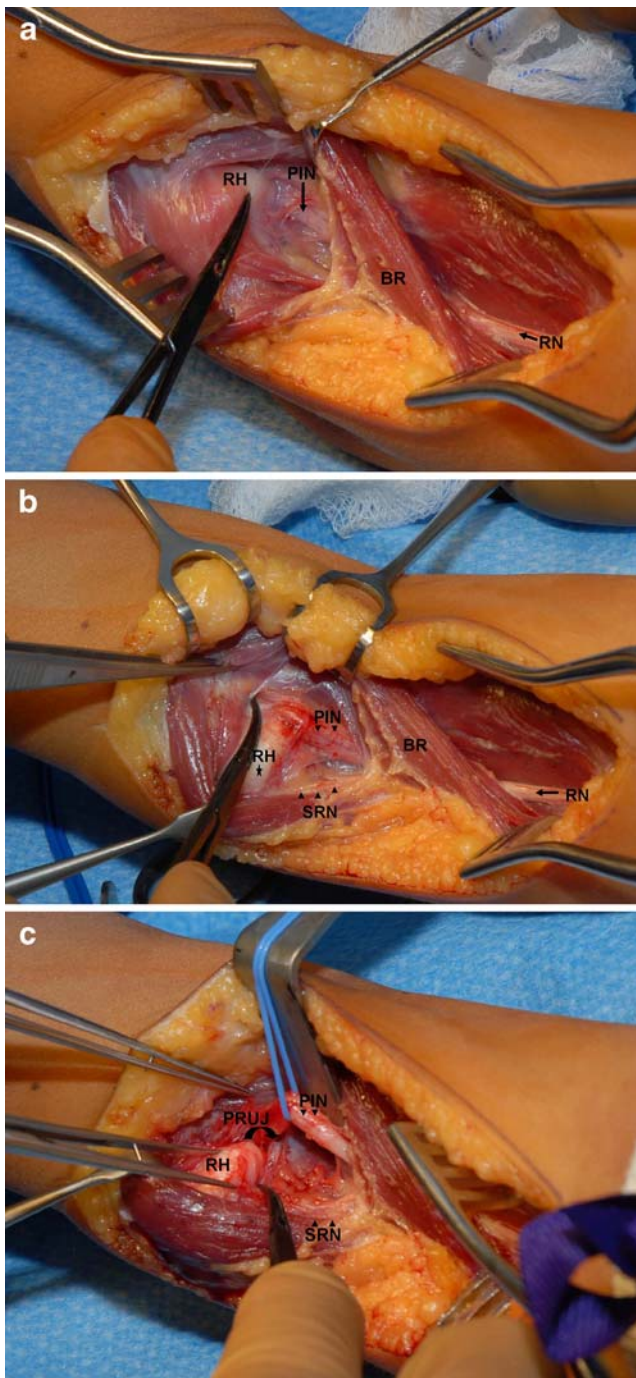
able. Electrodiagnostic studies confirmed a left PIN neuropathy. Motor nerve conduction studies failed to record compound muscle action potentials in the left radial nerve forearm–elbow segment, and electromyography of PIN-innervated muscles demonstrated membrane instability and no motor units. Sensory nerve action potentials of the left radial nerve revealed normal amplitudes and conduction velocities. A physical therapy program was initiated, and the patient was followed at monthly intervals. Repeat clinical and electrodiagnostic evaluations at 3 months following the initial study revealed no interval change.

At 9 months following the original injury, the patient underwent exploration of the left PIN and reconstruction of the chronic Monteggia fracture-dislocation. An anterolateral approach was utilized. The radial nerve was first identified between the brachialis and brachioradialis at its emergence from the lateral intermuscular septum. Distally, the bifurcation was identified, and the PIN was explored to the level of the arcade of Froshe. The radial head was found anteriorly dislocated between the superficial radial nerve and PIN. The PIN was subluxed posterior to the radial head and encased in thick scar adherent to the capsules of the proximal radioulnar and radiocapitellar joints (Fig. 2). Chronic compressive changes of the nerve and epineural fibrosis were visualized at these sites of capsular cicatrix and at the arcade of Froshe. Intraoperative neurophysiologic recordings were attempted, but given the time elapsed since the initial injury, recordable distal responses from the PIN-innervated muscles were not obtained, and the anatomy in this case did not allow studying the neuroma in continuity. A complete microsurgical neurolysis was performed (Fig. 2).

Next, the Kocher interval between the extensor carpi ulnaris and anconeus was utilized to expose the radiocapitellar joint. Reduction of the radiocapitellar joint was initially prevented by the interposed capsule, torn annular ligament, and scar tissue, and these soft tissues were resected. A corrective ulnar osteotomy was then performed

in order to obtain anatomic reduction of the radial head. Annular ligament reconstruction was performed utilizing a proximally based strip of periosteum harvested from the proximal ulna. The annular ligament reconstruction was tensioned to allow for smooth pronation and supination without any dislocation of the radial head throughout a full range of motion. Transcapitellar fixation of the reduced radial head was performed with a 3/32" smooth Steinman pin to maintain the radial head reduced against the capitellum and reduce stress on the soft tissue reconstruction. The lateral capsule was repaired and the incision closed in layers. A long arm cast with the forearm in full supination and the elbow maintained in 90° of flexion was applied. Electrical muscle stimulation to the wrist and extrinsic thumb and digital extensors was immediately initiated through a window in the cast. The postoperative course was uneventful.

Serial postoperative radiographs demonstrated maintenance of reduction of the radiocapitellar relationship, and at 6 weeks postoperatively the long arm cast and Steinman pin were removed. Radiographic evidence of delayed union was seen at 6 months postoperatively, and the patient underwent revision surgery with plate fixation. At 6 months following the revision surgery, radiographs revealed three cortices of osseous healing at the ulnar osteotomy site with maintenance of the radiocapitellar relationship (Fig. 3). The patient is currently pain free at the elbow, forearm, and wrist, and abundant callus is palpable along the subcutaneous border of the ulna. At 12 months following neurolysis of the radial nerve, the patient demonstrates excellent clinical evidence of return of function of the posterior interosseous nerve. There is full active wrist extension without deviation and full active digital metacarpal–phalangeal joint extension with mild residual weakness of the extensor pollicis longus and abductor pollicis longus (Medical Research Council [MRC] 4/5). Clinical examination further demonstrated full active ulnohumeral flexion



**Fig. 2** Intraoperative step-wise radial nerve exploration and neurolysis. **a** Identification of the radial nerve (*RN*) proximally between the brachialis and brachioradialis (*BR*). The brachioradialis was split distally to identify the terminal bifurcation; **b** subluxation of posterior interosseous nerve (*PIN*) posterior to radial head (*RH*). Dense capsular cicatrix encasing the *PIN* within the proximal radioulnar and radiocapitellar joints was seen. The radial head was found anteriorly dislocated between the superficial radial nerve (*SRN*) and *PIN*; **c** microsurgical neurolysis.

and extension. Active forearm rotation consisted of full supination and 30° of pronation.

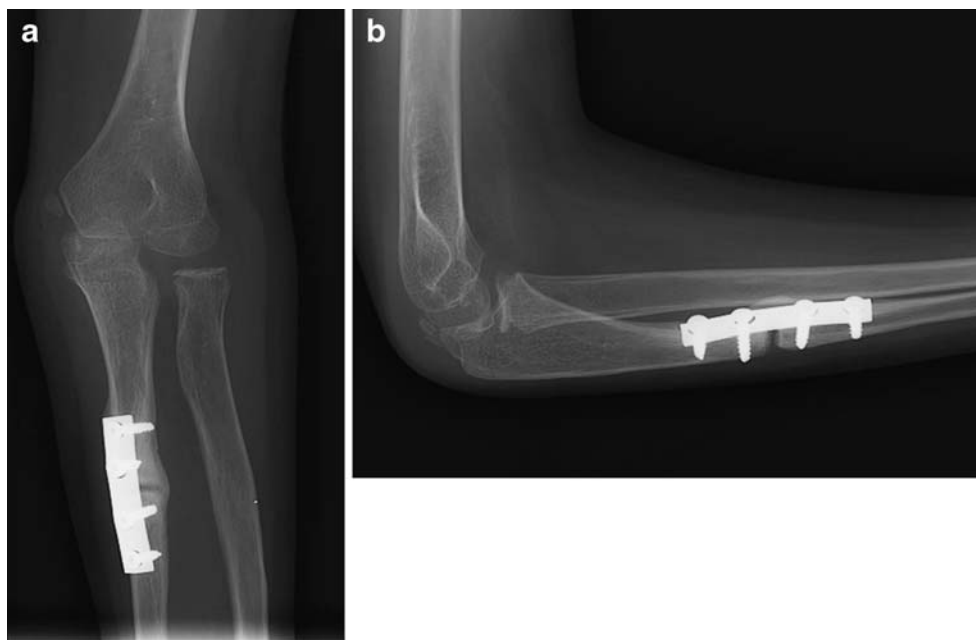
## Discussion

In 1814, Monteggia first described the association of radial head dislocation with a concomitant fracture of the ulna [25]. Several classifications [2, 10, 23, 25, 41] have been presented for Monteggia fracture-dislocations. Bado's classification [2] is well established in clinical orthopaedic practice, subdividing Monteggia fracture-dislocations into true Monteggia lesions (types I–IV) and equivalent lesions. Bado type I lesions, with anterior dislocation of the radial head and concomitant anterior angulation of the ulnar diaphyseal fracture, are the most common Monteggia fracture-dislocations in the pediatric population and constitute approximately 70% of Monteggia fracture-dislocations [6, 10, 12, 23, 27, 20, 30, 31, 41].

In the presented case, it is unclear if the radial head dislocation was appreciated and closed reduction achieved at the initial treating institution. Orthogonal radiographs obtained 3 months following the initial injury revealed chronic anterior dislocation of the radial head and malunion of the ulna. The high incidence of redislocation of the radial head after either spontaneous [21, 40] or closed reduction [10, 29] despite cast immobilization requires serial anteroposterior and lateral radiographs of the elbow be obtained and the radiocapitellar relationship evaluated with the radiocapitellar line on each film.

Operative treatment of Monteggia fracture-dislocations is necessary when closed reduction is unsuccessful in patients seen more than a month after the injury (i.e., chronic radial head dislocation). Chronic disruption of the PRUJ continues to represent a challenging clinical scenario for the pediatric upper extremity surgeon. Outcomes following surgical reconstruction of chronic pediatric Monteggia injuries vary [8, 9, 13, 14, 22, 32, 38], and parents should be counseled appropriately regarding the unpredictable results associated with late reconstruction. In a review of seven patients, Rodgers et al. [32] reported three good, two fair, and two poor results following operative treatment of chronic Monteggia lesions at a mean of 12 months from the time of injury. All patients had decreased forearm pronosupination arcs. Gyr et al. [13] observed variable improvements in flexion–extension and pronosupination arcs, but no functional deficits were reported. Recurrent anterior subluxation of the radial head occurred in four of 15 elbows. In a series of eight children with missed type I Monteggia equivalent injuries, David-West et al. [8] achieved good clinical and radiographic results in five patients following open reduction of the

**Fig. 3** Progressive bridging calus following plate fixation is seen at the prior delayed union osteotomy site. The radiocapitellar relationship remains reduced at 12 months following open reduction of the radial head and annular ligament reconstruction on orthogonal anteroposterior (a) and lateral (b) radiographs.



radial head, annular ligament reconstruction, transcapsular fixation, and ulnar osteotomy. However, overall mean pronation and supination were limited, measuring 43° and 61°, respectively. In contrast, Degreeef and De Smet [9] reported excellent outcomes in six children with missed Monteggia injuries following open radial head reduction and dorsal opening wedge ulnar osteotomy. Synostosis was not seen in the presented case, and series dedicated to outcomes in children with chronic Monteggia injuries do not indicate that synostosis is a common complication following surgical treatment.

Though limited to retrospective series with small cohort sizes, several groups have reported satisfactory clinical and radiographic outcomes following various combinations of annular ligament repair or reconstruction [3, 8, 32, 38], ulnar osteotomy [8, 9, 18, 20, 33, 37] (with [32, 38] or without bone graft; with [8, 9, 11, 13, 14, 22, 32, 38] or without [4, 20] fixation), and radiocapitellar [4, 8] or radioulnar temporary Kirschner wire fixation. Often, as seen in our case, reduction of the radiocapitellar joint is possible only following resection of the interposed capsule, torn annular ligament, and fibrous scar tissue within the proximal radio-ulnar and radiocapitellar joints and an ulnar diaphyseal osteotomy. In this patient, following reconstruction of the annular ligament, transcapsular fixation [8] was used to maintain the radial head reduced against the capitellum. The necessity for fixation of the ulnar diaphyseal corrective angular osteotomy remains debatable [4, 20]. Internal fixation options include a plate and screw construct [13, 32, 38], intramedullary devices [8, 13, 32] (i.e., Kirschner wires, Rush rod), and external fixation [11, 14, 22]. Cast

immobilization was unsuccessful in this case, but osseous union was evident at 6 months following revision with plate fixation of the ulnar osteotomy site. Acute or gradual ulnar lengthening [11, 16] (typically, 2–3 mm) is preferable to radial shortening to compensate for the proximal migration of the radial head. Late reconstruction should be limited to patients without dysplastic changes of the radial head (i.e., radiocapitellar incongruence).

Acute [15, 19, 35, 36, 39] and tardy [1, 17, 24] palsy of the PIN have been reported as the most frequent neurologic complications following these complex injuries about the elbow. Following the acute injury and anterior dislocation of the radial head, direct trauma and traction neuropraxia are implicated [36]. However, several authors [5, 15, 35, 39] have reported that these acute neuropraxias resolve with observation following closed reduction of the radial head.

Persistent, chronic PIN palsy in the setting of a chronically dislocated radial head is an exceedingly rare entity and is reported only twice in the literature [7, 28]. Osamura et al. [28] reported a case of a persistent PIN palsy that failed to improve following ulnar osteotomy for a missed Monteggia fracture. Delayed neurolysis demonstrated incarceration and rupture of the PIN within the RCJ. Chang et al. [7] reported a chronic PIN palsy due to a wraparound injury of the nerve on the unreduced radial head. Isolated cases [26, 34] of radial nerve/PIN interposition within the PRUJ, RCJ, or both following radial head dislocation preventing closed reduction of acute Monteggia injuries have also been reported. We hypothesize that the pathophysiology of the persistent PIN palsy in the patient reported here is multifactorial. With chronic anterior dislocation of the radial head, a compressive



neuropathy develops secondary to cicatrix overlying the capsule of the RCJ and PRUJ. Additionally, the dislocated radial head creates chronic compression at the arcade of Froshe through a tethering effect as the PIN passes between the two heads of the supinator.

Based on these reports [7, 28] and the intraoperative findings in our case, we recommend formal open reduction of the radial head and examination of the RCJ and PRUJ prior to ulnar osteotomy in the setting of reconstruction of the chronic Monteggia fracture-dislocation in order to identify PIN subluxation or incarceration. Early radial nerve exploration from the lateral intermuscular septum through its bifurcation to the level of the arcade of Froshe should be performed when neurologic deficits persist or worsen on clinical or electrophysiologic examination. Simultaneous treatment of the nerve and skeletal injury can result in a satisfactory outcome and obviate the need for later tendon transfers.

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