The Métaizeau Technique for Pediatric Radial Neck Fracture With Elbow Dislocation: Intraoperative Pitfalls and Associated Forearm Compartment Syndrome

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Abstract

Displaced radial neck fractures in the pediatric population can be treated with retrograde intramedullary nailing of the radius (the Métaizeau technique). This method allows early movement, which may improve functional outcome. Unfortunately, repeated intraoperative attempts with this treatment in challenging fractures can result in compartment syndrome.

In this article, we report the cases of 2 patients who underwent the Métaizeau technique for displaced radial neck fractures. In each case, optimal fixation of the radius was impossible because of concurrent elbow instability. Multiple attempts to reduce and stabilize these fractures may cause development or exacerbation of forearm compartment syndrome.

The Métaizeau technique has been shown to be an effective method of minimally invasive surgical management of pediatric radial neck fractures. Its success may hinge on the ability of the elbow joint to hold the radial head in position while the implant is driven into the proximal radius in a retrograde fashion. Care should be used when dealing with radial neck fractures associated with elbow dislocation, as they may be difficult to reduce and stabilize. The increased operative time and soft-tissue injury associated with repeated attempts with this method may lead to or worsen compartment syndrome.

Radial neck fractures are relatively uncommon pediatric injuries, comprising roughly 1% of pediatric fractures.[1] The radial neck fracture may be an isolated injury or in cases of significant elbow trauma may be seen with elbow dislocation or proximal ulna fracture. The treatment of these fractures can be challenging, as poor outcome can be associated with complications that include malunion, motion loss, avascular necrosis, nonunion, and cross-union. The literature includes few reports of compartment syndrome after radial neck fractures. In one report, 3 pediatric patients with compartment syndrome after radial neck fractures were all managed differently.[2]

The treatment path chosen for radial neck fractures depends on degree of displacement, ability to improve the displacement, and need for stabilization. In minimally displaced fractures, treatment is simple immobilization; in more displaced fractures, treatment is closed reduction and immobilization or open reduction with or without stabilization.[3] If possible, it is preferable to avoid open reduction, as a poor outcome is more likely encountered. Risks associated with open reduction include stiffness, nonunion, radioulnar synostosis, avascular necrosis, and damage to the physis.[4] It is debated whether these outcomes are caused by the severity of the trauma that tends to lead to open treatment or by the surgical trauma from the open procedures. Regardless, all efforts are made to avoid opening the radiocapitellar joint.

When closed reduction fails, invasive reduction can be achieved by "joy-sticking" the radial head into a reduced position with a wire or surgical instrument such as an awl or hemostat. Alternatively, the Métaizeau technique of retrograde intramedullary nailing of the radius can be quite effective in reducing and stabilizing the radial head. In this method, a retrograde wire is driven into the bone of the proximal radius, which can distract the fracture. Rotation of the impacted nail can translate the radial head into a more optimal position. Occasionally, a series of actions—rotating the rod, disimpacting the nail, derotating the nail, and reimpacting and rerotating the nail—is needed to fully reduce the radial head. Leaving the rod in the radius improves stability and may allow for early motion and possibly improved outcome. If the radial head cannot be reduced with this method, open reduction can be performed, and the radius can be stabilized for early motion with the intramedullary rod.[5,6] This method has shown great success in these patients, yet it is unclear if equally good results can be obtained for each radial neck fracture pattern with the

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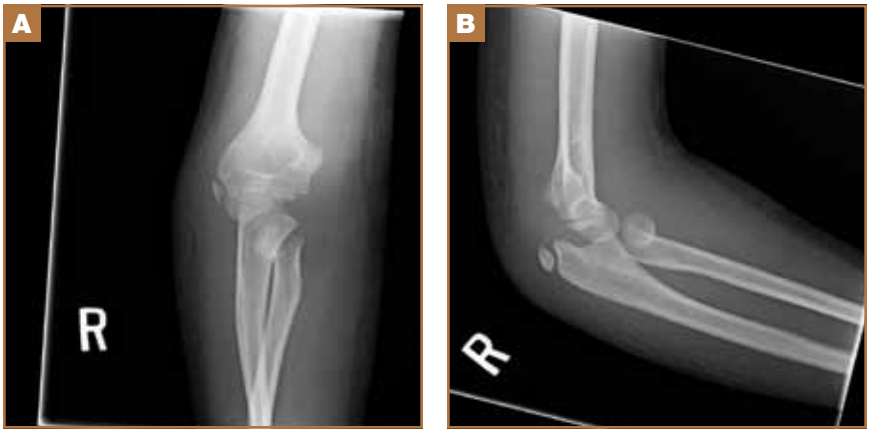

Figure 1. Anteroposterior (A) and lateral (B) radiographs taken in the emergency department show completely displaced radial neck fracture.

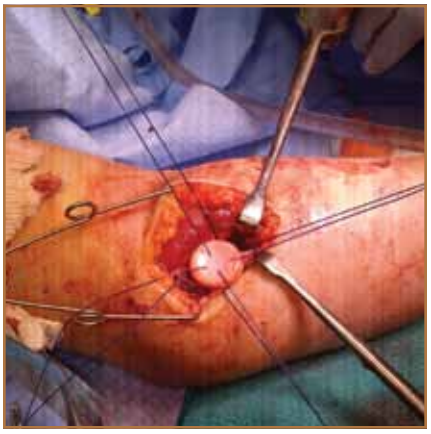

Figure 2. Suturing of radial head onto radial neck.

method described earlier. For instance, would more difficult treatment be encountered if the elbow were unstable?

Intramedullary fixation can be similarly used for displaced forearm fractures that fail conservative treatment. One particularly bad complication that may result is compartment syndrome.[7] Yuan and colleagues[8] hypothesized that repeated attempts to reduce and nail challenging forearm fractures could predispose to the development of compartment syndrome.[8] We are unaware of any reports of compartment syndrome arising from the use of intramedullary reduction and fixation of radial neck fractures.

In this article, we report on difficulties encountered with the Métaizeau method for radial neck fractures associated with elbow instability. Our repeated attempts to manage this fracture may have contributed to the development of forearm compartment syndrome in one case and may have worsened the syndrome in another. The patients' parents provided written informed consent for print and electronic publication of these case reports.

Case Series

Case 1

An 8-year-old girl presented to an outside facility after a fall from monkey bars onto her outstretched arm. Clinical examination revealed an elbow dislocation. The elbow was reduced and splinted, and the patient was transferred to our emergency department. On arrival, she was comfortable in the splint and had an intact neurovascular examination. Radiographs taken at our facility showed a dislocated elbow and a completely displaced radial neck fracture (**Figures 1A, 1B**). The splint was reinforced, and the patient was discharged home with instructions for elevation rest and plans for surgical reconstruction 4 days later.

In the preoperative holding area, she was comfortable and had intact neurologic and vascular function. In the operating room and before the arm was prepared, the elbow was swollen and ecchymotic, and the forearm compartments were swollen yet soft. After preparing and draping, the proximal radius was manipulated several times in a closed fashion. Although the alignment was improved with closed manipulation and joysticking the fracture, it was not considered adequate, and we proceeded with the Métaizeau method. A tourniquet was used during the case, inflated for 2 hours at 250 mm Hg. Multiple attempts to completely reduce and stabilize the radius with this method were thwarted by recurrent elbow instability. Although we managed to close the fracture, we were unable to impact the nail, as the elbow subluxated posteriorly each time the radial head was reduced and speared with the retrograde nail.

Given these difficulties, we performed an open lateral approach. The radial head, completely devoid of soft-tissue attachments, was reduced and sutured onto the radial shaft (**Figure 2**) and further stabilized with the intramedullary device (**Figures 3A, 3B**). After closure, the forearm volar compartment seemed tense, and compartment pressures measured 29 to 34 mm Hg. Based on these measurements and our previous experience (see case 2), we proceeded with an extensive deep and superficial volar fasciotomy where the muscles were swollen yet completely viable. The arm was splinted, and a vacuum-assisted closure (VAC; KCI, San Antonio, Texas) sponge and system were placed to reduce the swelling; the arm was further

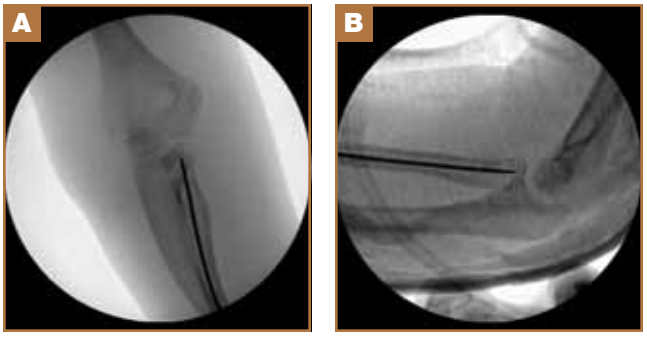

Figure 3. Final anteroposterior (A) and lateral (B) intraoperative fluoroscopic images after intramedullary stabilization of radial head.

immobilized with a posterior long-arm splint. Four days later, the patient underwent partial closure and split-thickness skin graft placement and immobilization in a splint with VAC sponge and system to encourage skin-graft adherence. She later had complete graft incorporation and was started on gentle elbow range of motion. At most recent evaluation, she had painless elbow range of motion from 20° to 110° with 60° of forearm rotation. Radiographs at 3.5-month follow-up showed interval subluxation of the proximal radial epiphysis (**Figures 4A, 4B**). Six-month follow-up radiographs showed unchanged subluxation of the radial head apophysis with bridging callus (**Figures 5A, 5B**). The patient was doing well clinically and reported no pain on activity. No further surgical interventions were pursued.

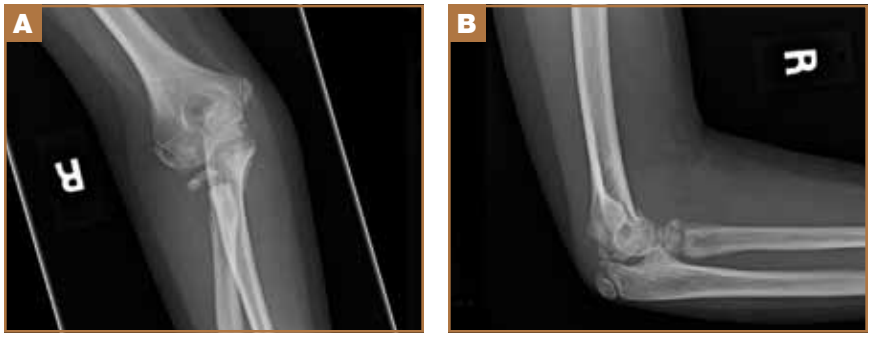

Figure 4. Anteroposterior (A) and lateral (B) radiographic images show interval subluxation of proximal radial epiphysis.

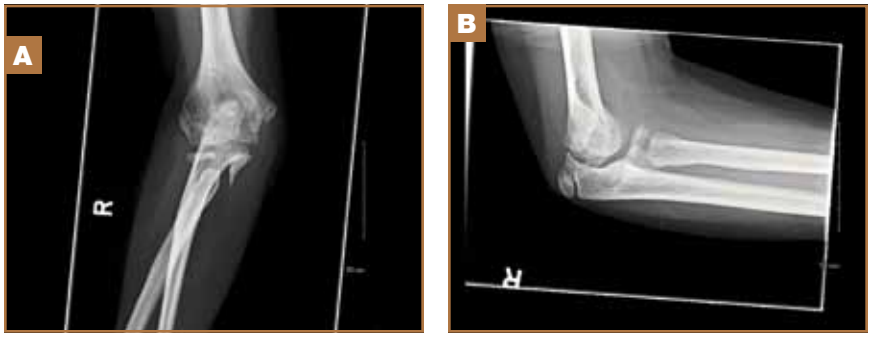

Figure 5. Anteroposterior (A) and lateral (B) radiographic images show persistent subluxation of proximal radial epiphysis and interval bridging callus formation.

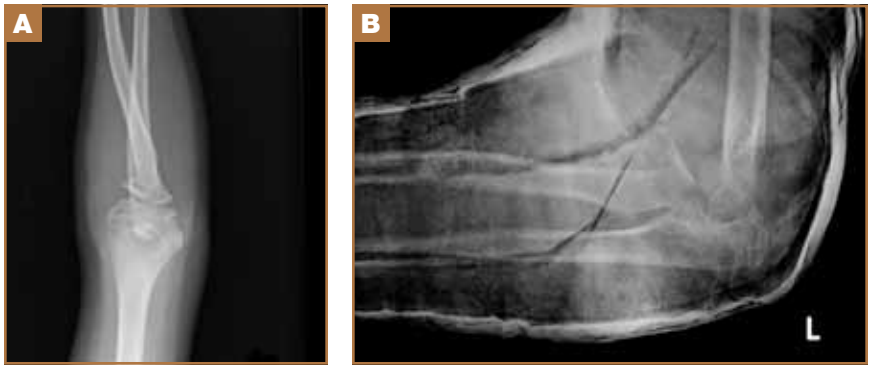

Figure 6. Anteroposterior (A) and lateral (B) radiographic images taken in emergency department show displaced Salter-Harris type II fracture of left radial neck.

Case 2

Six months before case 1, a 10-year-old girl presented to an outside facility with a displaced left radial neck Salter-Harris II fracture, which had been sustained in a fall from a horse. The patient was transferred to our emergency department. After a failed attempt to reduce the fracture there, she was admitted for a day of observation, sent home in a long-arm cast, and asked to return for operative intervention the next day (**Figures 6A, 6B**). In the preoperative staging area, she reported pain with extension of the fingers. In the operating room, volar forearm compartment pressures measured approximately 25 mm Hg (superficial compartment) and 45 mm Hg (further advancement). Given these findings, a superficial and deep volar forearm fasciotomy was performed. The Métaizeau technique was then used in an attempt to reduce and stabilize the fracture (**Figures 7A, 7B**). Although the method facilitated fracture disimpaction and partial reduction, fracture stability was poor with any rotation of the forearm. Despite multiple attempts to improve stability by impacting the rod deeper into the proximal radius, the fracture displaced as a result of posterior elbow instability, which had not been suspected before surgery. Eventually, the nail was maneuvered in a way that showed near anatomical alignment on imaging, and the arm was splinted in supination with a VAC suction sponge placed to decrease swelling over the fasciotomy site. After surgery, the patient continued to complain of significant pain with finger extension, and she was taken back to the operating room for reexploration and extension of the previous deep compartment forearm fasciotomy. Her postoperative course consisted of VAC sponge placement, and 2 returns to the operating room for eventual delayed primary closure. She was immobilized in a cast for 4 weeks. The implant was removed at 7 weeks, and dynamic fluoroscopic images taken at the time showed stability at the elbow joint after removal (**Figures 8A, 8B**).

Discussion

The Métaizeau technique has been shown to be an effective means of reducing radial neck fractures.[9] Compared with open

reduction, intramedullary fixation is less invasive, may have fewer complications, and may promote earlier mobility. Because of the retrograde insertion, later implant removal does not violate the elbow joint.[6]

Our 2 cases were vexing to treat because both patients had concurrent elbow instability, which made nailing and fixation challenging. The mechanics of the Métaizeau technique make it clear why patients with concurrent elbow instability may be at higher risk for failure. The technique involves retrograde insertion of a Kirschner wire or flexible nail through the medullary canal of the radius until the point is inserted into the inferior portion of the radial head using fluoroscopic guidance.[10] The implant can then be rotated to help reduce the radial head into place.[10] In our patients with concurrent elbow instability, during the impaction of the implant into the radial head, subluxation of the elbow prevented the advancement of the implant into the proximal radius, and therefore prevented stability.

Another unique feature of these patients was the association of compartment syndrome. One patient clearly developed compartment syndrome as a result of the technique. The other patient had full-blown compartment syndrome before treatment and underwent fascia release before application of the method. It is possible that this patient's need for an extensive deep volar release later that day resulted from the additional trauma that occurred with multiple attempts to perform the method. These cases may be similar to those of patients who were at increased risk for compartment syndrome because of intramedullary fixation of forearm fractures. In a retrospective study, Yuan and colleagues[8] evaluated 285 pediatric patients with both-bone forearm fractures. Of the 80 patients treated with intramedullary fixation, 6 later developed compartment syndrome—compared with no patients from the group that did not undergo intramedullary fixation. The patients who developed compartment syndrome had increased operative time and fluoroscopic exposure. The authors concluded that, in patients with not easily reduced fractures, conversion to open reduction should be performed early in order to minimize manipulation, operative time, and soft-tissue injury.

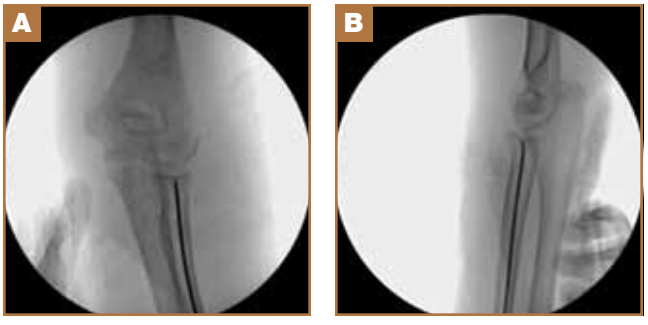

Figure 7. Anteroposterior (A) and lateral (B) intraoperative fluoroscopic image after intramedullary rod placement.

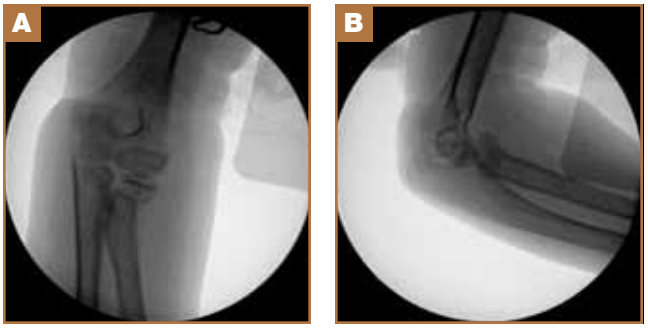

Figure 8. Anteroposterior (A) and lateral (B) intraoperative fluoroscopic images after hardware removal.

Conclusion

Although the Métaizeau technique is an effective means of providing minimally invasive surgical fixation of radial neck fractures, nailing may be difficult in fractures that also have a component of elbow instability. The increased operative time and soft-tissue injury associated with use of the Métaizeau technique in these patients could lead to or worsen compartment syndrome, and early conversion to open reduction should be considered in cases in which difficulties are encountered attempting the technique.

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This paper will be judged for the Resident Writer's Award.