Case Report

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Inadvertent Radial Head Inversion During Closed Reduction of a Pediatric Radial Neck Fracture

Zachary J. Sirois, BS
Sarah M. Kreul, MD
Craig F. Shank, MD

Abstract

Management of displaced pediatric radial neck fractures can be fraught with challenges. This unique case presents an 11-year-old female with a Salter-Harris type II radial neck fracture and how her radial head overturned 180° with the articular surface facing the radial shaft rather than the capitellum during closed manipulation under anesthesia. The malreduction subsequently required open reduction and highlights the importance of a careful stepwise approach to managing markedly displaced radial neck fractures. After closed reduction, meticulous assessment of intraoperative imaging when determining proper alignment is of the utmost importance as a result of the transverse nature of Salter-Harris type I and II fractures.

Level of Evidence: Level IV

From the Wright State University (Mr. Sirois), Boonshoft School of Medicine, the Department of Orthopedics (Dr. Kreul), Wright State University, and the Department of Orthopedics (Dr. Shank), Dayton Children's Hospital, Dayton, OH.

Correspondence to Mr. Sirois: Sirois.3@wright.edu

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Pediatric radial neck fractures have an incidence of 5% to 10% with respect to pediatric elbow fractures and represent nearly 1% of all pediatric fractures.[1] In such cases, angulation of >30° or notable translation typically necessitate surgical reduction.[1-4] It is generally accepted that closed reduction should precede open reduction whenever the case allows, but the factors that shift the treatment threshold toward open reduction continue to be debated.[2,3,5,6] Although the literature has notable case-control studies, it remains difficult to determine what independent factors will produce suboptimal outcomes after reduction.[2-5,7] Furthermore, abundant variation in fracture pattern occurs among these fractures, and specific complications associated with a particular radial neck fracture pattern remains relatively understudied.

We present a Salter-Harris type II pediatric radial neck fracture with substantial angulation and posterior displacement. A closed reduction was performed initially and thought to be effective after proper alignment was established. Further intraoperative inspection revealed that the radial head was overturned 180° with the articular surface facing the radial shaft rather than the capitellum. After this detection, a challenging open reduction was performed.

Case Report

An 11-year-old female presented to the emergency department with right elbow pain after falling on her outstretched right upper extremity. After physical and radiographic evaluation, the patient was found to have a Salter-Harris type II fracture of the radial neck with complete posterior dislocation and 90° angulation of the epiphysis on the radial neck (Figure 1). Direct surgical treatment was arranged with the provisional strategy of a closed reduction. Should closed reduction fail, the need for percutaneous versus open reduction was discussed with the patient and family.

After proper anesthesia and preoperative preparation, closed manipulation using the Patterson[8] maneuver was performed. With the elbow in extension and application of distal traction, the forearm was supinated and pulled into varus with simultaneous application of direct pressure over the radial head which brought the radial head back into alignment with the radial shaft. With the fracture "reduced," the articular cartilage of the radial head separated the metaphysis and epiphysis, giving the impression of a normal physis in this pediatric patient. Initially, the treating surgeons felt the reduction was successful and began preparing to cast the elbow. However, careful evaluation of final fluoroscopic images indicated that the radial head was flipped 180° with the articular surface facing the radial shaft rather than the capitellum (Figure 2). Close inspection shows that the false physis is wider than it should be at age 11, particularly given the maturity of the patient's other growth centers. Furthermore, the subchondral bone of the radial head articular surface is noticeably concave and thicker than the flat and indistinct bone of the metaphyseal surface.

After this detection, the need for open reduction was determined. With the forearm pronated, the extensor musculature was partitioned between the anconeus and extensor carpi ulnaris. The exposed joint capsule was incised proximally, revealing the capitellum, and extended distally. Open inspection confirmed the inversion of the radial head and positioning of the fracture surface against the capitellum. The epiphyseal fragment was surprisingly difficult to extract. Subsequently, the annular ligament was divided distally and retracted cautiously to avoid damage to the radial nerve anterior to the neck. After sufficient retraction, the radial head was extracted from the joint and placed in sterile saline. The joint was inspected and thoroughly irrigated, and the radial head was positioned back into proper position with the fracture surface facing distally (Figure 3).

A temporary Kirschner wire was placed in an antegrade fashion across the fracture site and down the radial shaft to maintain proper positioning of the radial head. After visual and C-arm inspection, a mini fragment 2-mm T-plate was contoured and placed over the lateral aspect of the radial head and neck so that it would not impinge on the proximal radioulnar joint. Two screws were placed through the plate into the head fragment and then across the fracture site into the metaphysis to avoid the articular surface. Furthermore, two screws were placed transversely into

Figure 1

Radiographs showing lateral (**A**) and AP (**B**) views of the patient's right elbow demonstrating complete posterior dislocation and 90° angulation of the radial neck toward the capitellum.

Figure 2

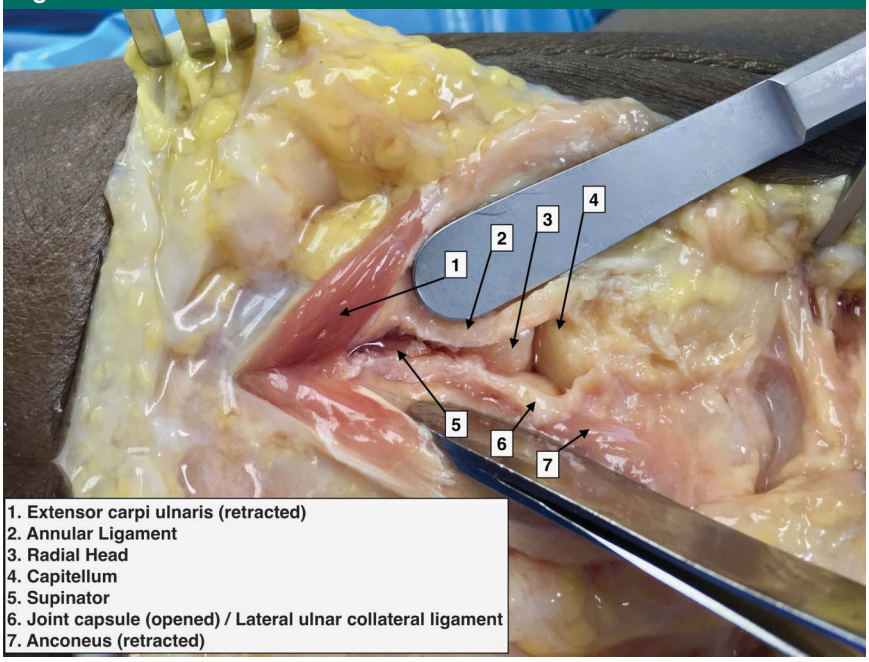
Fluoroscopic intraoperative imaging demonstrating the radial head overturned 180° with the articular surface facing the radial shaft rather than the capitellum, followed by open reduction and fixation of the fracture. Black arrows: articular surface of the radial head; white arrows: epiphyseal surface of the radial head.

Figure 3

A B

Radiographs showing AP (**A**) and lateral (**B**) views of the patient's right elbow 4 years after surgery demonstrating fracture union with intact fixation.

Figure 4



Cadaveric elbow model demonstrating the visible anatomy of a lateral approach (Kocher) during open reduction.

the radial shaft. C-arm fluoroscopic views in multiple planes were used to confirm the reduction alignment and implant position (Figure 2).

The radial neck fracture was stable to supination and pronation stress as well as flexion and extension. On extension and supination, the radial head dislocated posteriorly because of division of the annular ligament and its accompanying lateral ulnar collateral ligament. Consequently, the annular ligament was sutured, and the lateral ulnar collateral ligament was reattached to the lateral epicondyle. After this intervention, the elbow was stable through a range of flexion and extension with the arm in supination. After standard closure, the patient was placed in a well-padded posterior splint and transferred to the postoperative anesthesia care unit in stable condition.

At her 4-week appointment, the patient demonstrated full extension of the wrist and fingers. Sensation was intact to light touch in the radial, ulnar, and median nerve distributions. A 3-month follow-up after physical therapy revealed elbow range of motion of 4° to 150° with 90° and 76° of pronation and supination, respectively. The patient claimed to be pain free during exercise and resumed swim practice without deficits. Four years after surgery, the patient returned to the clinic for pain in her right elbow after a car accident. She reported no symptoms or functional issues before her injury. No notable acute injury was found, and her pain quickly resolved. She was noted to have normal flexion, extension, and pronation of her elbow and a mild deficit of supination (60°). Radiographs revealed good radiocapitellar alignment and no evidence of osteonecrosis or posttraumatic arthritis (Figure 4).

Discussion

Continued deliberation remains surrounding the surgical management of pediatric radial neck fractures.[2,3,5,6] A succinct appraisal of the literature and comparison of individual studies remains difficult as a result of dissimilar classification methods, surgical techniques, and perioperative protocol. Consequently, the elucidation of independent factors that will produce suboptimal outcomes after management remains difficult. This problem is compounded by the limitations of retrospective studies in separating confounding variables and selection bias including the generalized trend that only the most severe fractures tend to undergo open reduction. In one of the largest retrospective studies on pediatric radial neck fractures, Zimmerman et al[2] highlighted initial fracture

displacement and age greater than 10 years as notable predictors of poor functional outcome. In contrast, a recent study by Gutierrez-de la Iglesia et al[5] found initial fracture displacement to be the only notable predictor of poor functional outcome. Both studies encourage the use of open reduction to avoid percutaneous insults from repetitive manipulation failures. Although many large-sample studies indicate a correlation between open reduction and poor functional outcome, no study has reported open reduction as an independent negative predictive factor.[2-5,7] Consequently, many authors support the reconsideration of the previously established correlation between open reduction and poor functional outcomes.[6] The abundant variation in pediatric radial neck fractures and relative unpredictability of management results emphasizes the importance of highlighting rare complications that assist surgeons in avoiding poor outcomes.

This is the first reported example of 180° radial head inversion as an intraoperative complication during reduction of a pediatric radial neck fracture. The transverse nature of Salter-Harris type I and II fractures makes this inverted position possible and also difficult to appreciate on imaging. The epiphysis of the proximal radius is an almost symmetric disk, and reversal of the head could certainly be missed in an immature patient who is expected to have a physis between the two fragments. Fortunately, this complication was identified before leaving the operating room and was corrected with a good long-term outcome. The long-term consequences of an unrecognized inverted radial head are not known but would be expected to include articular surface damage, nonunion, and stiffness. Once this complication is recognized, open reduction is necessary to restore normal anatomy. Because of the instability of the fracture and the skeletal maturity of the patient's elbow, the senior author chose to repair the fracture using a plate and screws; however, this strategy would not be attractive in a younger patient. A number of fixation options have been advocated after open reduction of a radial neck fracture in an immature patient.[9] If the fracture is relatively stable, cast application without fixation has demonstrated good results.[10] A transarticular pin through the capitellum and radial head has been recommended, but this technique may result in breakage of the pin and difficulty retrieving the fragments. The Metaizeau technique involves use of an intramedullary pin or elastic nail to both reduce and stabilize the fracture and has been shown to yield excellent results.[11] Many authors use an oblique pin or pins across the fracture site, either antegrade or retrograde, and this approach is the preferred fixation method at our institution in immature patients. Bioabsorbable pin fixation has also been advocated in both children and adults to avoid implant-related complications and the need for implant removal.[12]

In conclusion, this case provides insight on recognizing and managing a notable intraoperative malreduction of a displaced radial neck fracture when initial closed reduction fails. Furthermore, it emphasizes the importance of meticulous assessment of intraoperative imaging when determining proper alignment of grossly unstable, transverse Salter-Harris type I and II fractures.

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