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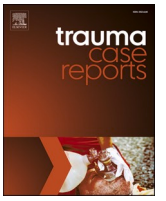

Case Report

13-year-old-male with a left open humerus fracture with concomitant intramuscular mid-substance biceps rupture: A case report

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ABSTRACT

A 13-year-old male presented with an open left humeral shaft fracture with intramuscular distal biceps rupture after being struck by a car. He underwent washout, humerus fixation, and open biceps repair. Immediate postoperative course was complicated by deep infection and failure of biceps repair. He subsequently required two additional surgeries. One year later, he exhibited full, painless elbow range of motion and biceps strength. This case is the first to report an open humeral shaft fracture with concomitant intramuscular, mid-substance biceps rupture in a pediatric patient. This was successfully treated with a full functional recovery.

Introduction

In the pediatric population, humeral shaft fractures are relatively uncommon, as they comprise of approximately 0.4 to 3 % of all pediatric fractures [1]. Further, fractures of the humeral shaft constitute approximately 20 % of all pediatric fractures of the humerus [2]. Distribution is typically bimodal, with most occurring under the age of three or above the age of twelve [1]. Mechanism of injury may vary from birth trauma, sports injuries, motor vehicle accidents (MVAs), or pathologic fractures through benign bone tumors or cysts. Humeral shaft fractures in patients younger than three years of age should raise suspicion for non-accidental trauma [3].

Most humeral shaft fractures in children are treated nonoperatively due to robust remodeling potential. Acceptable alignment parameters typically include: 1–2 cm of shortening, <20 degrees of varus/valgus angulation, < 20 degrees of anterior-posterior angulation, and <15 degrees of malrotation [4]. Indications for operative treatment include open fractures, bilateral upper extremity fractures, vascular injury, “floating elbow” injuries [5]. Operative treatments may involve open reduction internal fixation (ORIF) with plate and screws, flexible intramedullary nailing, or external fixation [1].

Complications of humeral shaft fractures in children may include radial nerve palsy (approximately 5 % incidence), vascular injury, and malunion or nonunion [6]. Open humeral shaft fractures carry significant risk of radial nerve injury, infection, and possible nonunion [6].

We present the first reported case of an open humeral shaft fracture with concomitant intramuscular, mid-substance biceps rupture. This required operative intervention including irrigation and debridement, ORIF, and open biceps repair.

The patient was informed that data pertaining to this case would be collected and submitted for publication. Informed consent was

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Fig. 1. (a-c): Clinical photos of patient's left open humeral shaft fracture on initial presentation.

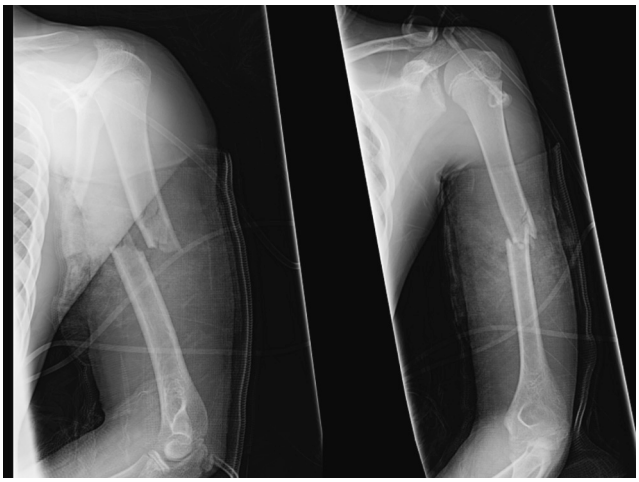

Fig. 2. (a-b): Left humerus plain film radiographs on initial presentation.

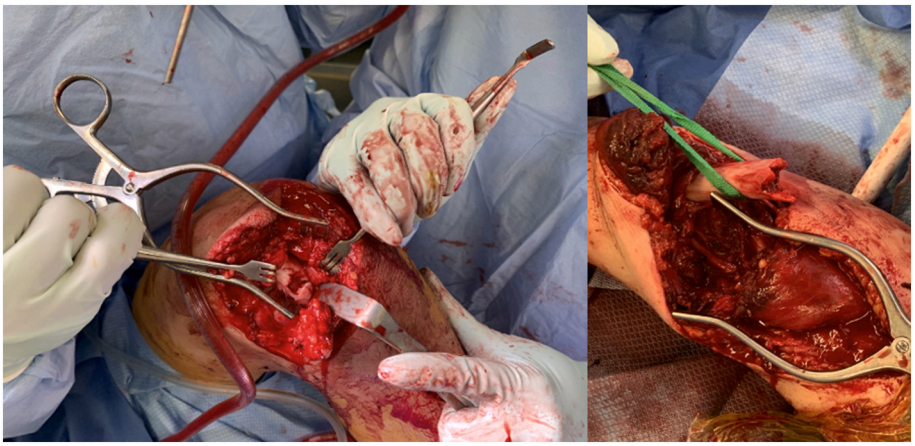

Fig. 3. (a-b): Intraoperative photos from initial surgery involving irrigation and debridement and surgical stabilization. Complete biceps mid-substance tear is demonstrated.

Fig. 4. Clinical photo of patient returning nine days after index surgery, with purulent drainage from surgical incision.

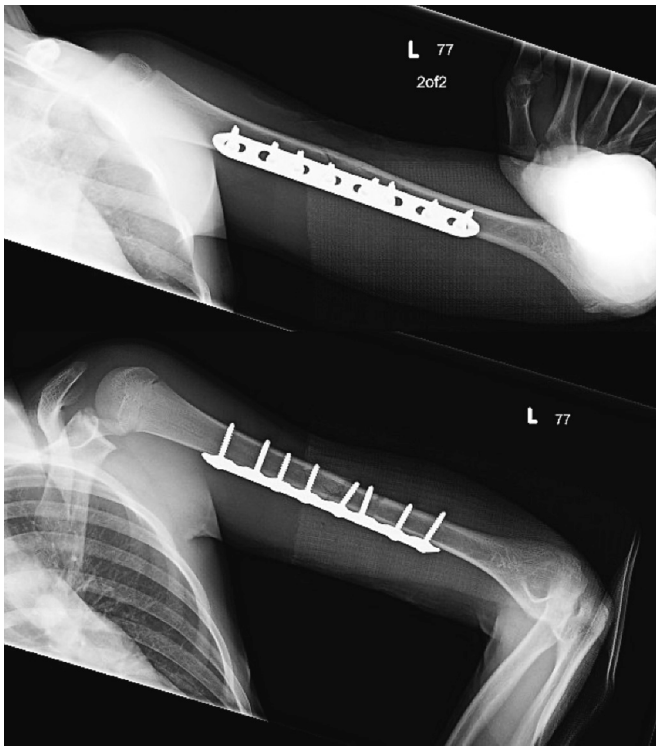

Fig. 5. (a-b): Left humerus plain film radiographs nine days after index surgery, when patient re-presented with signs of infection.

obtained.

Case

A 13-year-old-male with no known past medical history presented after being struck by a car. He presented with several orthopedic injuries: an open left humeral shaft fracture (Fig. 1 depicts clinical photos of the wound; Fig. 2 depicts plain film radiographs), left knee osteochondral fracture, and left open patella fracture. The patient was intubated and sedated on presentation to the emergency department, and therefore, a thorough neurovascular assessment could not be made. However, the patient had a palpable radial pulse. He was taken for open treatment of left patella fracture, irrigation and debridement to left open humeral wound, and surgical stabilization of left humerus fracture.

As for his left open humeral shaft fracture, the wound and constituent soft tissues were copiously irrigated and debrided. Intraoperatively, a mid-substance, complete intramuscular biceps tear was noted (Fig. 3). The radial nerve was identified to be contused where it passed beyond the fracture site posteriorly; however, it was in full continuity throughout the course of the nerve. Next, the fracture was reduced and stabilized with a 4.5 mm narrow large fragment plate.

Attention then was directed at open repair of the intramuscular, mid-substance biceps rupture. Proximal and distal ends were identified. Ethibond sutures were used in a running Krackow fashion while the elbow was held in hyperflexion. All six sutures were

Fig. 6. Size of soft tissue defect after irrigation and debridement in operating room, nine days after index surgery. Wound vac sponge placed during this surgery.

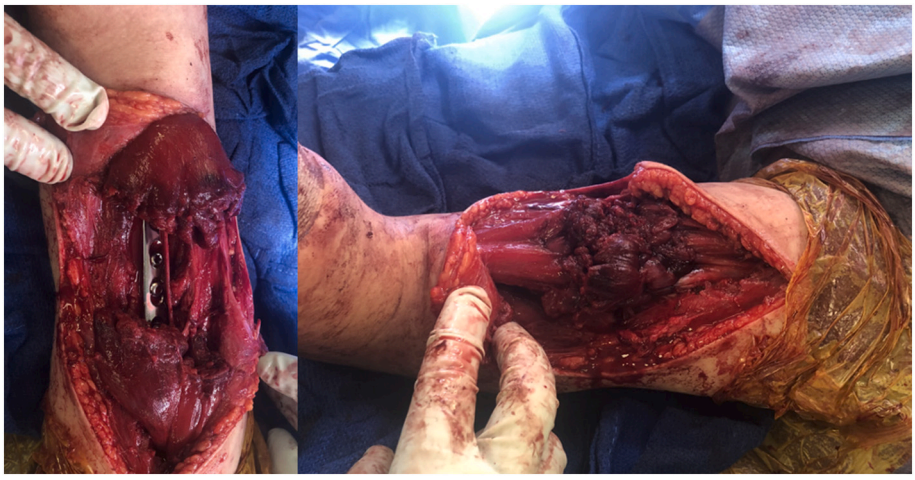

Fig. 7. Clinical photos taken during the biceps rupture (7a) and repair during the subsequent operation.

then tied with the proximal corresponding limb repaired to the distal corresponding limb. Once all six suture tails had been fully tensioned and tightened, the elbow was taken through a gentle range of motion from approximately 80 degrees short of full extension to full flexion with no noted gapping about the biceps repair site. Wound closure ensued, followed by placement into a splint in 100 degrees of flexion. Postoperatively, the patient was extubated and was observed to be distally neurovascularly intact in radial, ulnar, and median nerve distributions.

Nine days after the index surgery, the patient presented due to purulent drainage from the surgical wound (Fig. 4). Plain film

Fig. 8. Postoperative clinical photo after repeat wound exploration, repeat irrigation and debridement, revision open biceps repair, and wound closure (twelve days after index surgery).

radiographs are depicted in Fig. 5. He was taken to the operating room for wound exploration and irrigation and debridement. Intraoperatively, it was noted that the biceps repair had failed. Deep tissue samples were sent for culture. The area was debrided, leaving a large soft tissue defect (Fig. 6). A wound vac was then placed. He was placed on antibiotics postoperatively that were narrowed to ciprofloxacin once cultures speciated to Enterobacter and Citrobacter.

He was taken back to the operating room three days afterwards for a repeat wound exploration, repeat irrigation and debridement, revision open biceps repair, and wound closure (Fig. 7a and b depict the intrasubstance biceps rupture and subsequent repair). He was treated with oral ciprofloxacin per the pediatric infectious disease recommendations. He was made platform weight-bearing to the left upper extremity in a splint with a lateral side strut, with the arm flexed to 100 degrees to protect the intact brachialis muscle. At twelve days postoperatively, his wound was healing appropriately (Fig. 8).

At his first postoperative visit 2.5 weeks after his first surgery (six days after the repeat debridement and revision open biceps repair), the surgical incision was healing well. At seven weeks after his first surgery (5.5 weeks since the repeat debridement and revision open biceps repair), plain film radiographs showed fracture healing and no hardware complications (Fig. 9). At this time, his weight bearing status was advanced to weight bearing as tolerated for activities for daily living, and he began gentle active and passive range of motion exercises; occupational therapy for static dynamic extension splinting was also initiated. The patient returned at 14 weeks after his first surgery (12.5 weeks since the repeat debridement and revision open biceps repair) and was able to actively range his left elbow from full flexion to 10 degrees shy of full extension; he had full pronation and supination. At this visit, his weight bearing status was advanced to weight bearing as tolerated, except for heavy lifting.

He completed five total months of oral antibiotic therapy with ciprofloxacin. He was advanced to full weight bearing with no restrictions nine months after his index surgery. At this clinical visit, he lacked two degrees of terminal extension. Subsequently, at his

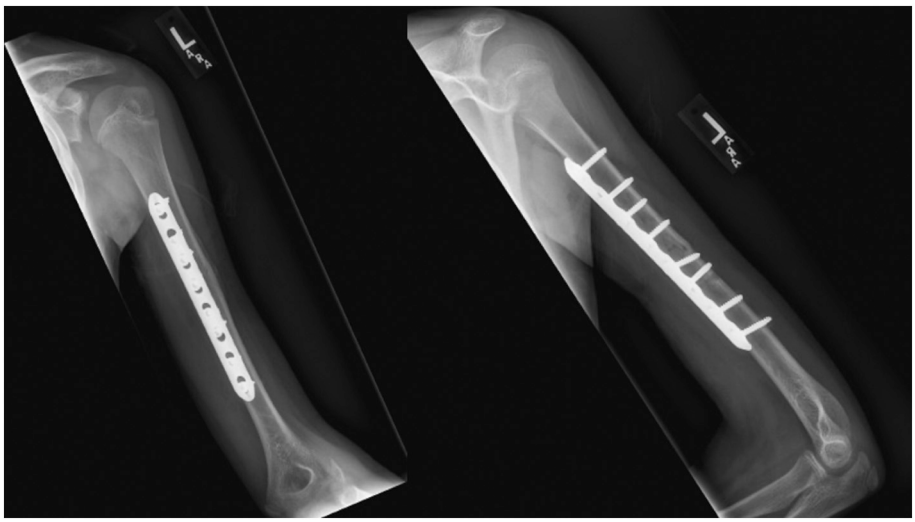

Fig. 9. (a-b): Plain film radiographs of left humerus seven weeks after index surgery depicting intact hardware and healing fracture.

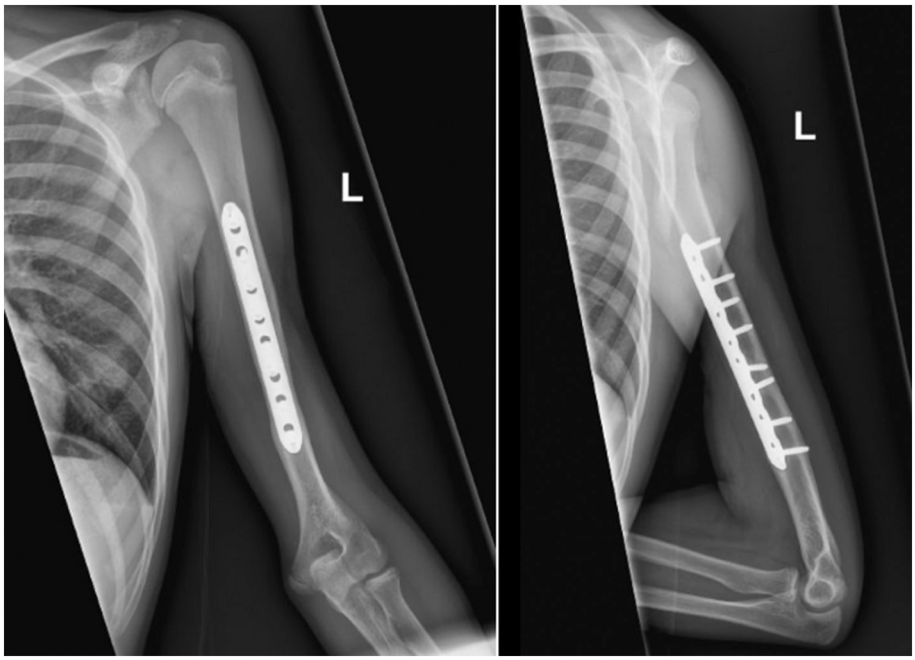

Fig. 10. (a-b): Plain film radiographs of left humerus one year after surgery, showing healed fracture without signs of hardware failure.

most recent clinic visit (one year after his index surgery), he had full flexion/extension to the left elbow, 5/5 biceps, supination, and pronation strength, and was playing sports without limitation. Plain film radiographs from his one-year follow-up appointment are shown in Fig. 10, and clinical photos depicting his most recent range of motion are depicted in Fig. 11.

Discussion

Humeral shaft fractures in the pediatric population are uncommon. Etiology may include non-accidental trauma, sports injuries, motor vehicle accidents, or pathologic fractures through benign bone tumors or cysts [1]. Most humeral shaft fractures in younger children can be managed non-operatively due to excellent remodeling potential. However, clear operative indications exist such as neurovascular injury, open fractures, bilateral humeral fractures, upper extremity compartment syndrome, or simultaneous injuries to the forearm constituting a “floating” limb [7,8].

In the literature, one prior report was published involving a patient with a distal biceps rupture with an ipsilateral both bone

Fig. 11. (a-c): Clinical photographs depicting patient's healed scar and range of motion at most recent follow-up.

forearm fracture [9]. To the best of the authors' knowledge, we present the first case of an open humeral shaft fracture with a concomitant mid-substance, intramuscular biceps rupture. Infectious disease team recommended a total of five months of oral ciprofloxacin for this patient. Our case demonstrates the importance of interdisciplinary team management in the case of surgical site infections after treatment of an open fracture [10,11].

In our case, the radial nerve was found to be in continuity during the index surgery, and the patient exhibited no neurologic deficits. Per the literature, radial nerve injury is less common among humeral shaft fractures in children when compared to adults. A previous study showed a radial nerve palsy rate of 4.8 % among pediatric humeral shaft fractures [12].

Further, intrasubstance biceps rupture is a rare injury, and a challenging problem in the younger patient. In the literature, most of these injuries occur in the setting of water sports or military parachuting [13–15]. Previous case reports have suggested the use of core, interrupted sutures with augmenting the periphery with double Kessler sutures [16,17]. Re-approximating muscle bellies with double right-angle sutures and augmenting the repair with a U-shaped biceps fascia flap has also been elucidated [18]. A recent report also discussed the role of using human dermal collagen matrix over the repair area to decrease the risk of suture pull-out [18]. If repair is not possible, salvage options remain limited, and may include a nonanatomic biceps to brachialis repair or use of Achilles tendon allograft for reconstruction [19].

Conclusion

To the best of the authors' knowledge, we present the first reported case of an open humeral shaft fracture with ipsilateral intramuscular, mid-substance biceps rupture. Our case highlights the challenges with managing a complex injury in a pediatric patient and the importance of interdisciplinary team management. A successful outcome was achieved for the patient, as defined by a full and unrestricted return to sports, no motion or strength deficits, and no pain.

CRediT authorship contribution statement

Neil Pathak: Conceptualization, Data curation, Funding acquisition, Supervision, Validation, Writing – original draft, Writing – review & editing. **Xuan Luo:** Conceptualization, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Matthew D. Riedel:** Conceptualization, Data curation, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding disclosure statement

No financial support was provided for this study, and there was no study-specific conflict of interest for any co-authors.

Declaration of competing interest

The authors do not have any financial or personal relationships with other people or organizations that could inappropriately influence or bias our work. All authors have nothing to declare. There was no financial support for this paper. There was no use of generative AI in writing of this paper.

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