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Case report

Proximal tibia triplane fracture: A serious presentation of a serious injury

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1. Introduction

Triplane fractures of the distal tibia are well-described injuries occurring in the adolescent population, but triplane fractures of other bony regions, including the proximal tibia, are infrequent and not as well described. Only a relatively few reports of proximal tibia triplane fractures exist in the current orthopaedic literature, all with benign clinical courses and two part fractures.[2,6,9,11] These injuries are rare, but when they occur, they can lead to major morbidity for a patient given the vicinity to the knee joint and accompanying neurovascular structures. We report a case of a severe proximal tibia triplane fracture treated with open reduction and internal fixation along with an associated compartment syndrome of the leg requiring a four compartment fasciotomy. The parents of the patient were informed that data concerning the case would be submitted for publication and they consented.

2. Case report

An 11-year-old girl presented to our outpatient orthopaedic clinic after being transferred from an outside orthopaedic office for evaluation of a unilateral proximal tibia fracture. The patient sustained the fracture after running into a guardrail while sledding without loss of consciousness or other head trauma. She was initially evaluated at a local emergency department where her clinical exam and radiographs were thought to be benign and she was told to follow-up with the local orthopaedic surgeon. At the patient's follow-up exam with the orthopaedist 2 days after discharge, a CT scan was obtained to fully evaluate the fracture. Due to the complex fracture pattern, the patient was subsequently transferred to our tertiary care Level-I trauma center for definitive management of her injury. At the time of her initial evaluation at our institution, the patient reported numbness on the dorsum of her foot with accompanying tense compartments and extreme pain with passive toe plantar flexion. Compartment pressures of the lateral and anterior compartments at the time measured 40 and 42 mmHg, respectively. The posterior and deep posterior leg compartments were also clinically tense but compartment pressures were not measured given the patient's already high pain level. Her dorsalis pedis and posterior tibialis pulses were strong and the limb was well perfused.

Review of the plain radiographs and CT scan of the knee demonstrated a comminuted proximal tibia triplane fracture as depicted by a medial Salter-Harris IV component with lateral Salter-Harris III fragment in the coronal plane and a large Salter-Harris II fragment that included the tibial tubercle with posterior displacement of the distal piece in the sagittal plane (Fig. 1(CT)). Given the severity of the injury mechanism and delayed clinical diagnosis of a compartment syndrome of the leg, the patient was admitted to the hospital and brought urgently to the operating room where a four compartment fasciotomy of the leg was performed along with open reduction and internal fixation of the fracture. The fasciotomy release was performed first. Initially a closed reduction attempt was made of the sagittal Salter-Harris II fragment to correct the posterior displacement but such efforts ultimately failed, necessitating open reduction through an anteromedial approach. Periosteal tissue, a portion of the pes anserinus soft tissue structures and medial collateral ligament were found within the fracture and removed, allowing appropriate fragment reduction. An anterolateral approach to the anteroposterior Salter-Harris III fragment was performed without arthrotomy and reduced anatomically as determined by fluoroscopy. Smooth Steinmann pins along with partially threaded cannulated screws were utilized to secure all fracture fragments (Fig. 2). Multiple pin fixation was necessary to fixate all fragments given the large size of the patient.

Post-operatively, the patient required an additional operative debridement of her open fasciotomy wounds in the operating room and she was discharged once the wounds appeared healthy and clean at hospital day number five. The knee and leg were secured in a hinged knee brace locked in full extension for 2 weeks after which full range of motion was allowed. The patient began partial weight bearing at 5 weeks and was advanced to full weight bearing at 10

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Fig. 1. (a) Anteroposterior CT scan of left knee, demonstrating Salter-Harris III fracture fragment. (b) Lateral CT scan of left knee, demonstrating Salter-Harris II fracture fragment, avoiding tibial tubercle apophysis. (c) Axial CT scan of left knee, demonstrating "Mercedes-Benz" three-point star configuration of triplane fracture.

weeks post-operative. Given the amount of muscle swelling after fasciotomy, the fasciotomy wounds were treated with wet to dry dressings twice daily with delayed closure of the lateral and medial fasciotomy wounds performed post-operatively at 2 and 4 weeks, respectively. Percutaneous pins were removed at 4 weeks post-operative. The patient went on to heal her injury without further incident and the cannulated screws were electively removed 3 months post-operative once healing was complete as depicted by radiography. Radiographs obtained at last visit, 12 months after initial injury, demonstrated full fracture healing but with early presence of a lateral physeal bar formation (Fig. 3). International Knee Documentation Committee (IKDC) and Tegner–Lysholm outcome scores were obtained at the time and determined to be 75 and 95, respectively. The patient reported that she could perform most strenuous activities until pain occurred. When her pain did occur it tended to be very severe and constant but did not limit her daily activities; the activities that affected her most were kneeling on the front of her knee and walking up stairs. Given the overall benign scores she received, it was thought that her pain was due mostly to her body habitus and continued muscular conditioning of the extremity as her discomfort was only with activity. She denied the presence of numbness or weakness in her leg or foot at most recent follow-up with manual muscle strength testing equivalent on both sides and knee range of motion from 10° to 110° and no knee laxity.

3. Discussion

Triplane fractures of the distal tibia are commonly found in adolescents, occurring distinctly in this patient population due to the unique pattern of physeal closure.[10] There is a widely recognized pattern beginning with central physeal closure followed by anteromedial, then posteromedial, and finally lateral closure.[10] A similar pattern is thought to occur in the proximal tibia physis as well.[2] The term triplane comes from the nature of the fracture occurring in the sagittal, coronal, and axial planes.[3] Distinct fracture patterns occur in relation to the position and rotational forces placed on the foot at the time of injury.[10] Specific patterns include two-, three-, and four-part fractures with multiple fracture fragments occurring at the joint due to axial loading at the time of injury.[3] As with all fractures involving the physeal growth plate, long-term follow-up is necessary until growth maturity occurs. If premature physeal closure occurs at the ankle joint, the resulting deformity is usually insignificant as the patient is already of enough advanced age that any resulting deformity is unlikely to be symptomatic.[10]

Although triplane fractures of other joints have been reported in the literature, most notably those of the distal humerus,[7] the distal radius,[8] and the hand,[4] they are infrequent. A triplane fracture of the proximal tibial physis has also been reported and described but to a lesser degree of morbidity as our current

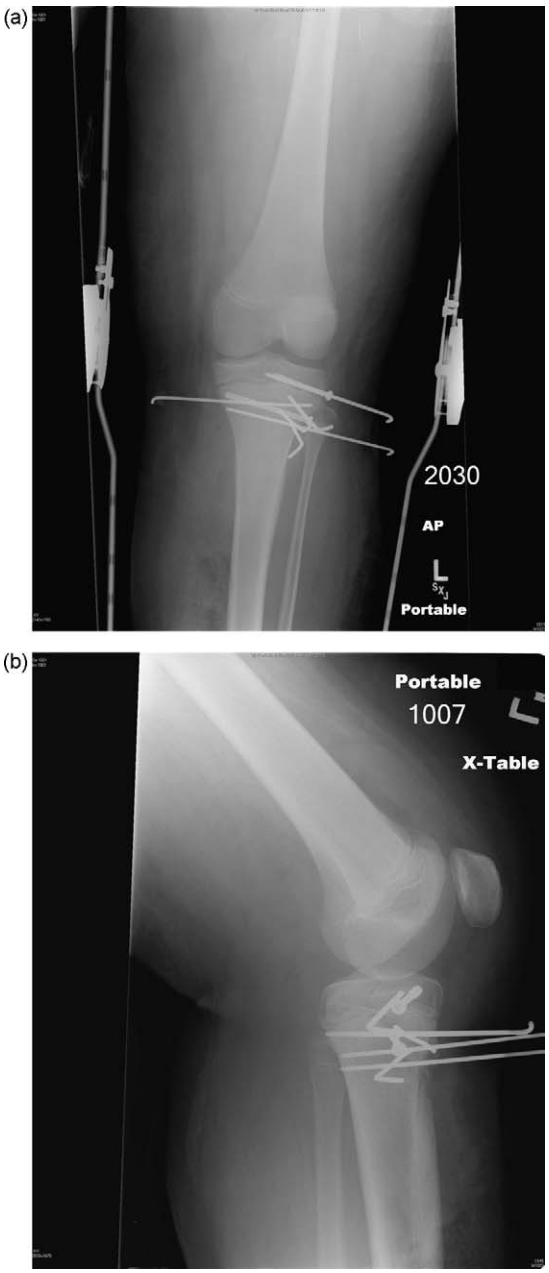

Fig. 2. (a) Post-operative anteroposterior radiograph of left knee. (b) Post-operative lateral radiograph of left knee.

patient.[2,6,9,11] Fractures of the proximal tibial physis and epiphysis are usually the exception rather than the rule as the knee ligamentous insertions occur at the metaphyseal region of the tibia where stress and subsequent fractures typically occur rather than at the physis.[2] Thus, physeal knee fractures are usually high energy injuries. Because of the proximity of adjacent neurovascular structures at the knee, such injuries expose affected patients to significant potential morbidity including nerve damage, vascular insult, and compartment syndrome. Current estimates of such complications included a 5 percent risk of popliteal artery injuries, a 3 to 4 percent risk of compartment syndrome, a 5 percent risk of peroneal nerve injury, and approximately 25 percent risk of growth arrest leading to angular deformity and possible limb length discrepancy.[5] Any posterior displacement of a proximal tibial physeal injury is the equivalent to an adult knee dislocation, and an arterial injury must be suspected in all patients presenting with such a fracture pattern.[14] Therefore, careful examination and neurovascular monitoring are essential in displaced fractures around the pediatric knee. The potential for acute and delayed compartment syndrome even in minimally displaced proximal tibia fractures is significant and appropriate clinical monitoring is vital, including pressure measurement if suspicions ensue.[5]

The fracture patterns described by previous reports of the proximal tibial triplane fracture included two part fractures.[2,6] Given the rarity of such injuries, other patterns have not been fully described or appreciated. In the current patient, a triplane fracture was clearly apparent given the appearance of a medial Salter-Harris IV fragment and a lateral Salter-Harris III fragment depicted on coronal plane CT imaging and a posteriorly displaced Salter-Harris type II fracture that included the tibial tubercle and anterior tibial metaphysis in the sagittal plane. The axial CT scan images also demonstrated what has previously been described as a ''Mercedes-Benz'' three-point star configuration in distal tibial triplane fractures. The importance of this entity is that it signifies a multi-fragment three part fracture pattern.[10] The reports by Conroy et al.[2] and Kanellopoulos et al.[6] describe two part triplane fracture patterns of the proximal tibia. Our current patient demonstrates that multi-fragment triplane fractures are possible at the proximal tibial physis and, as in the distal tibia, are likely due to axial loading of the joint at the time of injury. In contrast to the reports by Conroy et al.[2] and Kanellopoulos et al.[6] the triplane pattern in our patient was multi-fragmented; the sagittal piece was a Salter-Harris II fragment that appeared to include the anterior metaphysis and tibial tubercle and was separated from the lateral Salter-Harris III fragment on coronal imaging. The Salter-Harris II fragment appeared to be the Salter-Harris IV fragment seen on coronal views, resulting in the ''Mercedes-Benz'' appearance on axial imaging. Also in contrast to previous reports, the comminuted fracture pattern could not be reduced closed due to blockage by the periosteal and pes anserinus soft tissues and required open reduction with extraction of the soft tissues. Our patient also presented with a delayed compartment syndrome, depicting a higher energy injury with added patient morbidity unlike those proximal tibial triplane fractures already described.

The 12-month post-operative radiograph of our patient demonstrated the early presence of a lateral physeal closure. Although our particular fracture type has not been reported in the literature, similar high energy injuries of the proximal tibial physis are associated with a significant risk for complications including physeal growth arrest and angular deformity.[5] This behaviour is antithetical to the lesser morbid distal tibia triplane fracture where severe complications are infrequent and any resulting angular deformity is rarely symptomatic because these injuries usually present close to skeletal maturity.[10]

Despite the morbidity of the described injury, which included a compartment syndrome, delayed wound closure and partial physeal closure, our patient had an overall good to excellent outcome as determined by her scores on the IKDC and Tegner–Lysholm outcome scores. These scores were chosen for follow-up as they have been shown to be successful in determining general subjective outcomes for a variety of knee pathologies and procedures.[1,13] Though the patient's IKDC score was lower than females similar in age without a history of knee injury (normative data demonstrating an average score of 89),[12] her score on the Tegner–Lysholm outcome instrument determined her overall function to be excellent. The most significant drop in the IKDC score arose from stating that her pain, when present, was constant and severe, but the pain did not limit her daily activities. The current plan for the patient is continued close radiographic follow-up at routine intervals to follow the present

Fig. 3. (a) Twelve-month anteroposterior radiograph of left knee. Early closure of lateral physis can be appreciated. (b) Twelve-month lateral radiograph of left knee.

lateral physeal arrest and perform bar excision with fat interposition and possible medial physeal epiphyseodesis as necessary for any worsening angular deformity.

4. Conclusion

Proximal tibial triplane fractures are rare injuries but carry with them the need for clinical vigilance. These fractures are high energy injuries that can result in multiple intra-articular and physeal fragments that require individual anatomic reduction and stabilization in order to prevent future arthritis, pain, and deformity. Given the complex nature of the described injury, pre-operative CT scan is essential to appreciate the full severity of the fracture and identify all fragments requiring fixation. Because of the involvement of the physeal growth plate, long-term radiographic follow-up of the affected extremity is necessary to treat any angular deformity or leg length difference that might occur. Complex fractures of the proximal tibial physis should raise the suspicion for an underlying compartment syndrome, even one that is delayed, and all affected extremities require close monitoring with urgent treatment as dictated by clinical examination findings. Despite the high morbidity potential of this fracture, proper treatment of proximal tibial triplane fractures can lead to an overall excellent clinical and functional outcome.

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