Occult Distal Femoral Physeal Injury With Disruption of the Perichondrium

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Abstract: The authors describe a case of distal femoral physeal injury with disruption of the perichondrium in a 9-year-old girl after a sledding accident. The patient presented with knee pain, limited range of motion, and inability to bear weight. Initial radiographs were normal. A magnetic resonance imaging of the knee demonstrated abnormal signal and widening of the distal femoral physis with elevation of the posterior distal femoral periosteum. This case illustrates the main magnetic resonance imaging findings in an occult Salter Harris type I injury: increased physeal thickness and signal intensity on water-sensitive sequences, perichondrial disruption, and intracartilaginous fracture.

Key Words: physeal injury, perichondrial disruption, pediatric knee, intracartilaginous fracture

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Physeal fractures are common in children. Approximately 15% to 30% of all long bone fractures during childhood involve the physis.[1] It is important to recognize physeal components of fractures, as injury to the physis in a growing child can lead to the development of osseous bridging and growth disturbances of the bone.[2] While most physeal fractures can be obvious on plain radiography, physeal fractures of the knee, particularly the distal femur, can be very subtle or even radiographically occult. Magnetic resonance imaging (MRI) is often done in children with severe injury to the joints to evaluate the status of the ligaments, menisci, and articular cartilage; in any of these cases, there may be unsuspected fractures involving the physis. Occult physeal injuries are typically Salter-Harris type 1 fractures without displacement.

We present a case of a 9-year-old girl who sustained an occult distal femoral physeal injury with disruption of the perichondrium after a sledding accident.

CASE REPORT

A previously well 9-year-old girl had persistent left knee pain and limited range of motion after a sledding accident. She was seated in front of a sled, which collided with tree. The patient was unsure of the position of her legs; however, she immediately noted diffuse left knee pain and inability to bear weight. Physical examination revealed very limited range of knee motion with significant guarding. Pain was localized mostly over the posterolateral join line. She denied medial knee tenderness. There was no patellar sensitivity, and her neurovascular system was intact. She was unable to bear weight on her left leg.

Initial anteroposterior and lateral radiographs of the left knee were normal. A magnetic resonance imaging (MRI) of the knee was performed to evaluate for internal derangement. The MRI revealed no evidence of osteochondral, meniscal, or ligamentous injury. A coronal water-sensitive intermediate-weighted fat-suppressed image (Fig. 1) demonstrated that the distal femoral physis was widened compared to the proximal tibial physis and that the physis showed high signal intensity. Within the substance of the lateral physis was a line suggestive of a horizontal fracture through the cartilage (Fig. 2), compatible with a Salter Harris I fracture. Adjacent metaphyseal edema was also present. The sagittal intermediate-weighted image at the level of the anterior cruciate ligament (Fig. 3) demonstrated a tear of the posterior distal femoral perichondrium.

The patient was placed in a long leg cast. Follow-up radiographs at 6 weeks demonstrated interval healing with normal alignment. The distal femoral physis remained opened. The cast was subsequently removed, and she was placed in a knee immobilizer and began physical therapy. Radiographs obtained at 6 months after the injury demonstrated normal alignment with a normal-appearing distal femoral physis, without evidence of growth arrest or bony bar development. She was asymptomatic at that time.

DISCUSSION

The pediatric skeleton responds to trauma differently from adults. The weakest constituent in pediatric bones is the zone of provisional calcification, which is the transition zone between physeal cartilage and bone. Physeal cartilage is weaker than both bone and ligaments, often rupturing in the setting of trauma. The physis is the weakest when it is at its thickest, which is during periods of active growth, such as during puberty.[3] The periosteum consists of an outer fibrous layer of collagen and fibroblasts and an inner cellular layer of osteoprogenitor cells. The periosteum in children is thicker compared with that in adults and more loosely attached along the shaft but is tightly tethered at the level of the physis.[4] The perichondrial ring of LaCroix (perichondrium) consists of a thin ring of intramembranous bone and an outer fibrous layer, which supports the weak chondro-osseous junction. The perichondrium surrounds the main physeal cartilage, and it is necessary for the circumferential growth of the bone. It is continuous with the periosteum and is tightly tethered to the physis at the groove of Ranvier. Owing to the loose attachment, the periosteum is often stripped in the setting of trauma but is seldom disrupted. Large traumatic subperiosteal collections are common but typically stop at the perichondrium. It is important to note that 35% of all physeal bridges that require resection occur at the distal femur.[3]

The analysis of the fracture line within the cartilage can also have prognostic importance. In undulating physes like the distal femur, even a Salter-Harris type I fracture can involve the germinal zone. Experimental studies suggest that MRI can detect whether the fracture line remains within the hypertrophic zone

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FIGURE 1. Coronal water-sensitive intermediate-weighted fat-suppressed image of the knee shows widening of the distal femoral physis with high signal intensity (arrow). Adjacent metaphyseal edema is also present.

and zone of provisional calcification (and is not likely to result in growth arrest) or whether there is a more ominous involvement of the germinal and proliferative zones.[5] In this case, the fracture extended to the epiphyseal side of the physis.

On water-sensitive sequences, the normal growth plate is seen as a band of higher signal intensity (SI) between the low-SI epiphyseal bony plate and the low-SI zone of provisional calcification and primary spongiosa of the metaphysic.[6] Interruption of the growth plate is typically seen as a focal region of low SI within the bright physeal cartilage on fat-suppressed water-sensitive imaging.[7] Transverse fractures through the physis can have a wandering course within the cartilage that is detectable on MR images.[5] The periosteum is a thin low-SI (on all sequences) linear structure that parallels the cortex. The "metaphyseal stripe" or subperiosteal tissue is of high SI on water-sensitive sequences. The periosteum continues to the level of the perichondrium, at the level of the physis, which is also seen as a low-SI band on all sequences.[2] The perichondrial ring is generally thicker in appearance compared with the periosteum.

FIGURE 2. Coronal water-sensitive intermediate-weighted fat-suppressed image of the distal femur. Within the substance of the lateral physis, there is a line suggestive of a horizontal fracture line through the cartilage (arrow), compatible with a Salter Harris I fracture.

FIGURE 3. Sagittal intermediate-weighted image at the level of the anterior cruciate ligament shows a tear of the posterior distal femoral perichondrium (arrow). There is uplifting of the periosteum with a small subperiosteal collection.

In cases of knee trauma with high clinical suspicion of fracture, in the setting of normal conventional radiographs, MRI is extremely useful in the assessment of physeal trauma. Magnetic resonance imaging offers excellent visualization of the unossified growth plate cartilage and plays an important role in the evaluation of acute growth plate injury. In a large series of 315 consecutive pediatric patients with knee trauma, 9 patients (2.9%) had physeal fractures, with Salter Harris type II injury the most common.[8] Whereas periosteal elevation was seen in 6 of the 9 physeal fractures, there was no reported disruption of the perichondrium. In Salter-Harris type I fractures, there is a complete epiphyseal separation without an adjacent bone fracture. This uncommon type of fracture is usually seen involving the unossified epiphyses of the humeri in newborns and infants and are commonly displaced.[3]

Radiographically occult Salter-Harris type I fractures of the knee are uncommon, and disruption of the perichondrium is rarely recognized. This type of injury has not been fully described within the literature. We present this case to highlight the MRI features of a nondisplaced physeal distal femoral fracture with intracartilaginous fracture line and perichondrial disruption.

CONCLUSION

Occult physeal injuries are typically Salter-Harris type 1 fractures without displacement. This case illustrates the main MRI findings in an occult physeal injury: increased physeal thickness and T2 signal intensity, perichondrial disruption, and intracartilaginous fracture. It is important to recognize these findings, as

Salter-Harris injuries occur in nearly 3% of all knee MRI examinations in adolescents and may be occult on conventional radiography.

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