Entrapped periosteum preventing reduction of a Salter-Harris II distal tibial fracture in an adolescent patient. MRI and intra-operative findings

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INTRODUCTION

Physeal or growth plate injuries comprise 18% of all pediatric fractures, with Salter Harris type II as the most common type of fracture injury pattern observed in 61% of patients.[1–3] The incidence of growth arrest is just over 1%, and the incidence of serious complications is less than 1%.[2] Irreducible physeal fractures, caused by entrapment of the periosteum, tendons or ligaments, are of particular concern because of the potential interference with physeal growth that may lead to early closure.[4–6] Previously published case reports have described reduction blockage from entrapment of the medial collateral ligament (MCL),[5] the periosteum within the proximal tibial physis,[4] and interposition of the posterior tibial tendon within the distal tibial physis.[7] However, the literature lacks reports of both the MRI findings and intra-operative images of entrapped periosteum, preventing the reduction of a Salter Harris II fracture of the distal tibia. We present an adolescent boy with a Salter Harris II fracture of the distal tibia and entrapment of the periosteum within the physis diagnosed using MRI after failed closed reduction that required surgical excision. The diagnosis and management along with both the MRI and intra-operative findings are discussed. The patient and family were notified that the case would be published and consent was provided.

CASE REPORT

A 14-year-old boy sustained an injury when another player fell onto his right ankle while playing soccer. On initial presentation, the patient reported hearing a ''pop'' at the time of the injury and complained of right ankle pain. Past medical history, surgical history and review of systems were noncontributory. On physical examination, the skin was intact with significant edema. There was point tenderness to manual palpation along the lateral and anteromedial aspect of the right ankle. The patient had full motor function and sensation in all distributions of the right lower extremity, with 2+ dorsalis pedis and posterior tibialis pulses. Initial radiographs demonstrated a distal fibular fracture and a Salter Harris II fracture of the distal tibia, with widening of the medial physis of 8 mm as measured with the electronic picture archiving and communication system (PACS). Closed reduction under conscious sedation was performed in the emergency department, and the patient was placed in a sugar tong and posterior splint. Post reduction radiographs (Figure 1) showed residual valgus angulation of 15° of the distal fibular fracture, and significant residual widening (8 mm) of the anteromedial distal tibial physis remained.

MRI was obtained of the right ankle because of the persistent widening of the distal tibial physis after reduction. Multiple images were obtained that showed irregularity of the distal medial tibial physeal plate with significant widening, along with bone marrow edema within the growth plate. Furthermore, the low-signal periosteum covering the distal aspect of the tibia on the medial side was lacking on the T2-weighted coronal images (Figure 2). This periosteum was subsequently seen interposed within the distal tibial physis on both the coronal (Figure 2) and sagittal (Figure 3) T2-weighted MRI images. Other associated pathology seen with the MRI included rupture of the anterior talofibular ligament (ATFL) and a sprain of the flexor hallucis longus (FHL) tendon.

The patient was brought to the operating room for surgical excision of the entrapped periosteum. With the patient under general anesthesia, an incision was made over the right medial malleolus. The area of the tibial physis was carefully dissected down, and a large flap of periosteum was noted to be interposed (Figure 4) within the growth plate. Initially, it was difficult to remove the entrapped periosteum; therefore, a valgus stress was applied to the fracture site to facilitate removal. The segment of periosteum was subsequently excised; it measured approximately 2.5 cm × 2.5 cm and was sent for pathology (Figure 5). The wound was then thoroughly irrigated, closed in layers, and a short-leg cast was applied. The patient tolerated the procedure well and was discharged from the hospital on the first postoperative day.

The patient is currently 16 months from surgery and has returned to previous sports activities (soccer) without any restrictions. Physical examination demonstrated full motor function and sensation to light touch in all muscle groups and nerve distributions, respectively. There is no gross

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FIGURE 1. Post reduction anteroposterior radiograph of the right ankle in a plaster sugar tongue splint demonstrates a distal fibular fracture and distal tibial Salter Harris II fracture. There is still a significant widening (8 mm) of the medial distal tibial physis.

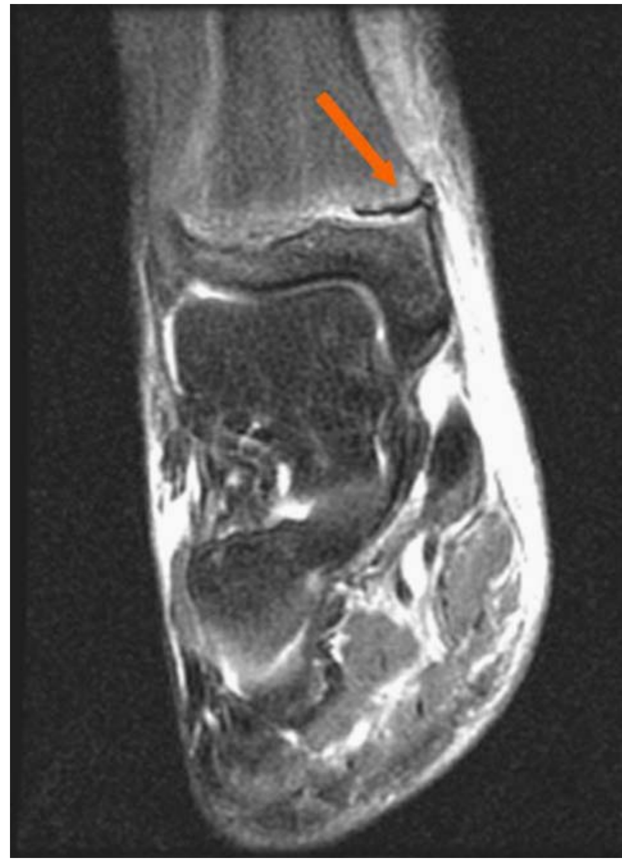

FIGURE 2. Coronal T2-weighted image shows that the dark signaled periosteum covering the distal aspect of the tibia on the medial side was lacking. This periosteum was flipped down and interposed within the physis (red arrow) resulting in significant widening.

malalignment of the right lower extremity. Anteroposterior radiographs of both the right (injured) and left ankle (uninjured) at the 16-month follow-up visit are seen in Figure 6. The orange arrows on the right ankle radiographs demonstrate the original injury site, which is now about 7 mm above the distal tibial physis.

DISCUSSION

Physeal or growth plate injuries typically are classified by the Salter-Harris classification system. It is used to estimate both the prognosis and the potential for growth disturbances. In this particular system, type I are fractures through the physis, while type II fractures extend from the physis into the metaphysis, type III fractures extend from the physis into the epiphysis, type IV fractures extend from the physis into both the metaphysis and the epiphysis, and type V fractures are a compression or crush injury to the physis.[8,9] Salter-Harris type II fracture is the most common type of physeal injury[1,3] and typically is caused by a supination and external rotation mechanism.[10] Although many studies note a high complication rate associated with Salter-Harris

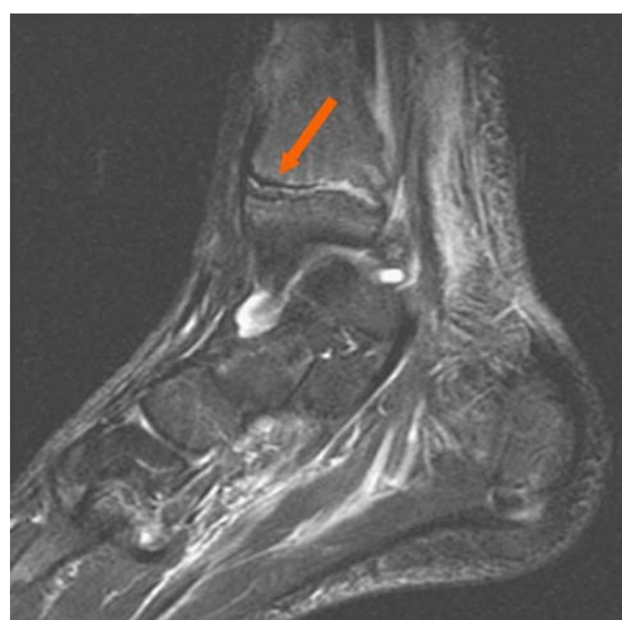

FIGURE 3. Sagittal T2-weighted image shows the dark signaled periosteum entrapped (red arrow) within the anterior distal tibial physis.

FIGURE 4. Intra-operative digital photograph showing the periosteum entrapped within the distal tibial physis.

type III and IV fractures,[11–13] Rohmiller *et al.*[14] identified premature physeal closure (PPC) in 39.6% of Salter-Harris type I and II fractures.[14] Angular deformity and leg-length discrepancies can be seen with asymmetric PPC or complete PPC, respectively.[15] Factors associated with PPC of the distal tibia are initial fracture displacement[14,16] and the mechanism of injury.[16] Both open or closed anatomic reduction of a physeal fracture to <2 mm of displacement has been shown to decrease the incidence of growth arrest and is recommended by several authors.[11,12,17,18] Furthermore, a residual gap at the physeal fracture site of greater than 3 mm after reduction will increase the rate of PPC to 60% compared with 17% if no gap is present.[11]

Our report presents a patient with a Salter-Harris type II distal tibial facture with entrapped periosteum and examines the identification, significance and management of this injury pattern. In a previous report by Whan *et al.,*[4] the use of MRI in the detection of periosteum interposed within the proximal tibial physis was described. In their report, plain radiographs showed widening of the posterior proximal tibial physis and an MRI demonstrated a Salter-Harris type I injury with an elongated focus of low-signal intensity on all sequences that extended 10 mm into the posterior aspect of the proximal tibial physis. This low-signal intensity was determined to be the entrapped periosteum, and subsequent surgical intervention confirmed this diagnosis. The entrapped periosteum in our patient was seen extending significantly into the growth plate on both the sagittal and coronal T1 and T2-weighted MRI images. McAnally *et al.*[5] described entrapment of a torn medial collateral ligament within the proximal tibial physis. Initial radiographs demonstrated medial widening of the proximal tibial physis with subsequent MRI showing soft tissue lodged in the medial physis. After surgical removal of the soft tissue and physis reduction, the patient's physis remained open at 16 months postoperatively with no evidence of PPC or physeal bar formation. The role of using MRI to detect physeal injuries is still evolving in the literature, and several authors recommend MRI in the setting of physeal injury or widening after reduction of an acute injury to aid in diagnosis and management.[4,5,19–21] Carey *et al.*[21] reported that the use of MRI in the setting of acute growth plate injury altered Salter-Harris staging and resulted in a change in the management of up to 33% of patients. Further advantages of MRI include the ability to detect avascular necrosis complicating physeal injuries and abnormalities in cartilage and bony bridges across the growth plates that may result in growth arrest.[4,22–25]

Although entrapped perisoteum has been described as a cause of irreducible reduction in physeal fractures as case reports at several different anatomic sites, including the distal radius,[26] proximal humerus,[27] distal femur[28] and proximal tibia,[4,29] our report is the first to provide both MRI and intra-operative images demonstrating interposition of the periosteum in the distal tibial physis in an adolescent patient. The patient's initial radiographs demonstrated significant widening of the anteromedial distal tibial physis in the presence of a Salter-Harris type II fracture. Barmada *et al.*[11] described the most significant risk factor for PPC after Salter-Harris types I or II fractures of the distal tibial physis was a residual physeal gap after attempted closed reduction. Five patients in their study who were treated surgically with excision of the entrapped peristeum had no evidence of PPC postoperatively. Our patient had a residual gap of 8 mm on the anteromedial tibial physis after closed reduction. An MRI was obtained to rule out soft-tissue interposition and demonstrated the low-signal periosteum interposed within the distal tibial physis on both the coronal and sagittal images, which created a block to our reduction. Some authors believe that the residual gap after reduction could also be caused by a rotational deformity.[30,31] Therefore, preoperative MRI can be essential in determining if this residual gap is caused by soft-tissue interposition or rotational malalignment. If the widening is caused by malreduction, then another attempt at closed reduction under anesthesia before open reduction is reasonable.

Surgical management of this condition is controversial. Premature closure of the physis and subsequent leg-length discrepancy is one of the greatest concerns with this type of

FIGURE 5. Intra-operative digital photograph showing the excised periosteum that measured 2.5 cm × 2.5 cm.

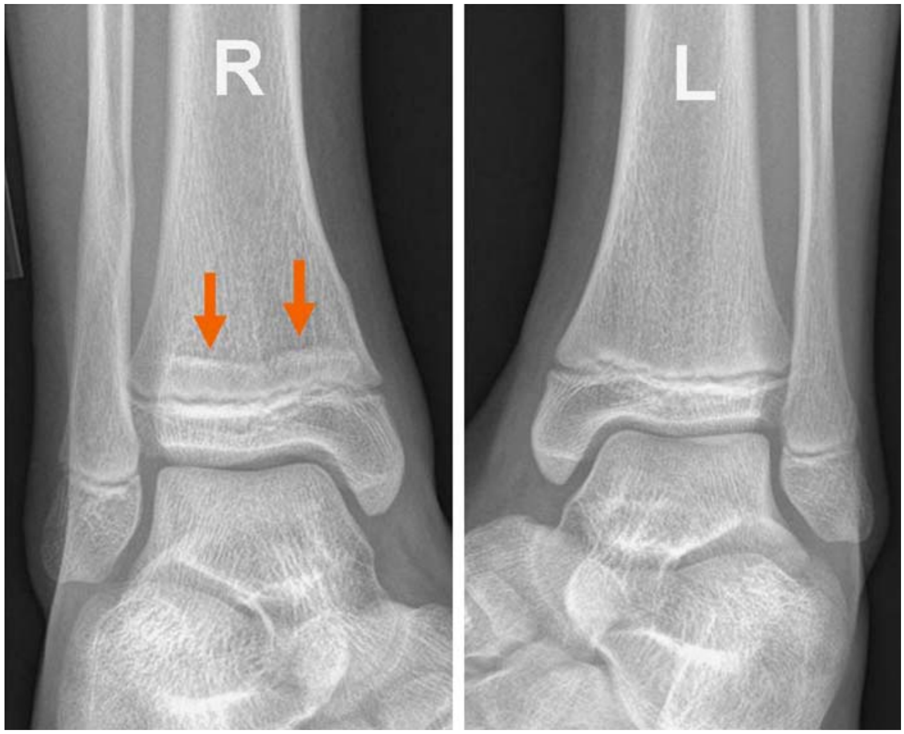

FIGURE 6. Anteroposterior radiographs of bilateral ankles at the 16-month follow-up clinic visit. The physis of the injured ankle on the right is open without any evidence of physeal bar formation or closure. Also, note the metaphyseal scar (arrows) of the previous injury seen about 7 mm above the physis.

injury. The exact mechanism of growth arrest remains unclear. Histologic studies have shown the occasional development of physeal bars but the cause of these bars and their role in growth arrest also are debated.[32–34] Wattenbarger *et al.*[34] evaluated the histologic features of proximal tibial physeal fractures and bar formation in rats. They found that fractures contained within the physis healed appropriately without bar formation, while fractures that extended from the physis to the epiphysis showed physeal disorganization, with physeal bar formation along vertical septa through primary osteogenesis. A follow-up study by Gruber *et al.*[32] found that the periosteum, when left within the physis, was treated as a foreign body and degraded by giant cells or alternatively the physis simply grew around it. They noted that if the physis remained intact, then it could repair itself despite the periosteum interposition, but a small leg-length discrepancy of 0.57 mm did result in a rat model. However, Phieffer *et al.*[33] also examined the role of interposed periosteum in proximal tibial physeal fractures of rats. They found that although physeal bars were more frequent in the group with interposed periosteum, the bar size was not affected by the periosteum interposition, and the bar formation did not predictably result in leg-length discrepancy. However, unrelated to bar formation, they did find a small, but statistically significant difference in the leg lengths of those rats with simple physeal fractures, <0.2 mm of leg-length discrepancy, and those with physeal fractures and periosteum interposed, >0.2-mm discrepancy. The clinical relevance of these differences in animal models remains unclear and indicates the need for a prospective study with extended follow-up to evaluate leg-length discrepancy in human patients with operative and nonoperative management of interposed periosteum.

In conclusion, this case report presents an adolescent patient with a distal fibular fracture and Salter-Harris type II tibial facture with entrapped periosteum diagnosed with MRI who underwent operative excision of the periosteum. We emphasize the importance of careful examination of plain radiographs for physeal widening, which may represent soft-tissue interposition or rotational malignment, especially if this gap persists after attempted reduction. In these circumstances, an MRI should be obtained. Interposition of dark or low-signal-intensity structure within a widened physis seen on multiple images may represent entrapment of periosteum or soft tissue. Although surgical management of interposed periosteum is debated, animal studies have demonstrated leg-length discrepancies, and residual physeal gaps have been shown to increase the risk of premature physeal closure.[11,32,33] In a patient with a residual widening of the physis after closed reduction, we recommend obtaining an MRI to determine the cause of physeal widening. If the residual gap is not caused by soft-tissue entrapment and limb alignment is maintained, then another attempt at closed reduction can be performed and conservative management may be followed. However, if MRI demonstrates soft-tissue or periosteal interposition, we recommend surgical excision of the tissue to prevent premature physeal closure or bar formation, leg-length discrepancy and potential angular deformity.

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