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CASE REPORT

Periosteal entrapment in distal femoral physeal fractures : Harbinger for premature physeal arrest ?

Lee S. Segal, M. Wade Shrader

From the Center for Pediatric Orthopaedics, Phoenix Children's Hospital, Phoenix, Arizona, U.S.A.

We report on two patients who sustained Salter-Harris II fractures of the distal femur with physeal widening after being tackled in football games. Pre-operative MRI indicated entrapped periosteum at the physeal fracture site for both patients.

Both patients underwent open reduction of the physeal fracture with removal of the entrapped periosteum and achieving an anatomic reduction. Follow-up MRI's revealed premature physeal arrest. Subsequent procedures were performed to address sequelae of premature physeal arrest.

The presence of physeal widening and entrapped periosteum may reflect high-energy trauma to the physis. This can result in injury to both the epiphyseal blood supply and to the physeal cartilage (germinal zone) resulting in physeal arrest despite anatomic reduction after removal of the entrapped periosteum. Upon literature review, pre-operative MRI demonstrating entrapped periosteum has not been previously reported.

We hypothesize that the presence of entrapped periosteum following distal femoral physeal fractures may be associated with an increased risk for premature physeal arrest.

Keywords : physeal fracture ; distal femur ; periosteal entrapment ; premature physeal arrest.

INTRODUCTION

Fractures of the distal femoral physis are uncommon injuries, reported to occur in only 0.3-1.4% of all growth plate injuries (*18,20*). This is fortunate, since this location has a high rate of complications such as growth disturbance, which ranges from 27 to 50% (*1,5,17,22,25*). The unique three-dimensional architecture of the distal femoral physis is considered a primary factor in this high rate of complications after physeal fractures (*11,22*).

The degree of fracture displacement, the quality of fracture reduction, metaphyseal comminution, and the age of the patient at the time of injury have been reported to contribute to increase the risk of growth disturbance (*1,3,10,11,14,17,22,26*). A frequent cause of distal femoral physeal fractures being irreducible is the presence of entrapped periosteum at the fracture site (*9*). Does the presence of periosteal entrapment in distal femoral physeal fractures also increase or contribute to the risk of growth disturbances ?

Recent literature on distal tibial physeal fractures has suggested that periosteal entrapment at the fracture site determined by a physeal gap or widening

■ Lee S. Segal, MD, Clinical Professor.
■ M. Wade Shrader, MD, Clinical Associate Professor.
University of Arizona College of Medicine – Phoenix, Phoenix Children's Hospital, Phoenix, Arizona, USA.
Correspondence : Lee S. Segal, Center for Pediatric Orthopaedics, Phoenix Children's Hospital, 1919 East Thomas Road, Phoenix, Arizona 85016, USA.
E-mail : lsegal@phoenixchildrens.com

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of ≥ 3 mm, may contribute to or increase the risk of partial or complete physeal arrest (*2*). Periosteal interposition has been reported in several other sites including the proximal humerus, distal radius, and proximal tibia (*16,19,27*). Animal models have been used to further evaluate the role of periosteal entrapment. These studies have concluded that physeal fractures with periosteal entrapment have a significant risk of developing a limb length discrepancy (*12,21,28*). The purpose of this preliminary report is to raise awareness that entrapped periosteum in distal femoral physeal fractures may be a direct or indirect risk factor for premature physeal arrest.

CASE REPORTS

Two case reports of periosteal entrapment in distal femoral physeal fractures, with widening of the physis on radiographs and documented in preoperative MRI studies, both of whom required subsequent surgical intervention for premature physeal arrest are described. The patients and families were informed that their cases would be submitted for publication and each provided consent for inclusion in this report.

Case 1

A 12+8-year-old male sustained a left knee injury after being tackled from behind during a football game. The leg was severely angulated laterally and without pulses at the scene of the injury. The pulses returned after the leg was re-aligned, and brisk capillary refill returned to the foot. Upon admission to the emergency department, the neurovascular status of the left leg was intact, with strong dorsalis pedis and posterior tibial pulses. The left knee was noted to be swollen and globally tender. Radiographs demonstrated a Salter-Harris II fracture of the left distal femur. He was placed in a bivalved long leg cast at an outside hospital, and referred to our institution. Radiographs revealed widening of the physis medially (Fig. 1). An MRI was obtained which demonstrated periosteal interposition on the medial side of the distal femoral physis (Fig. 2).

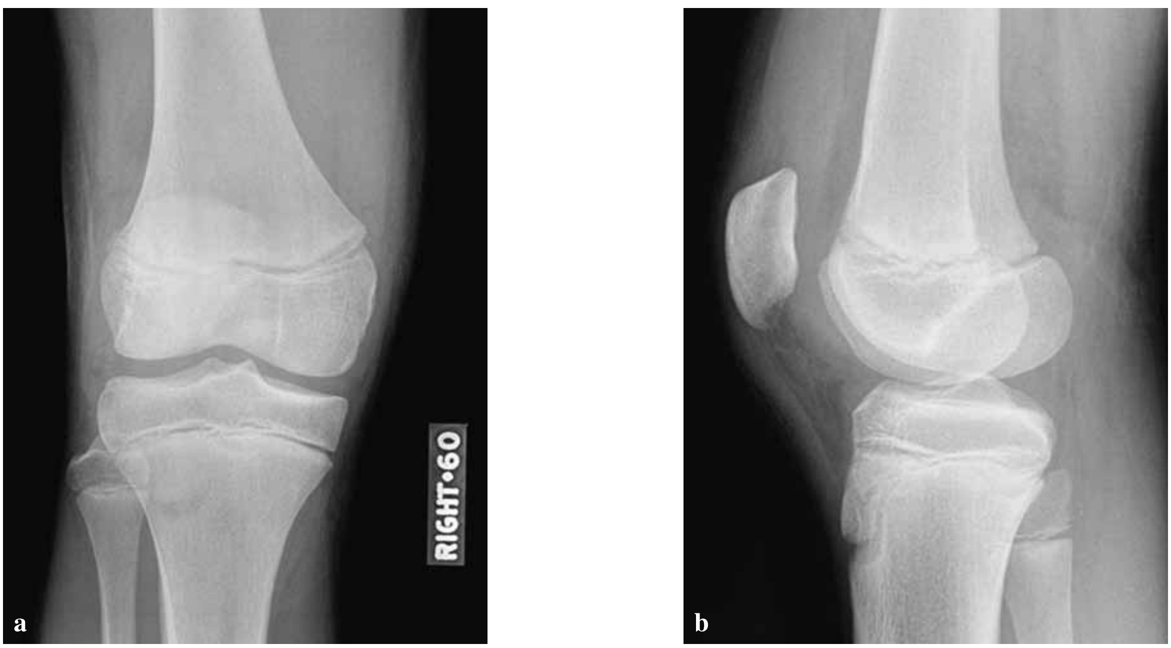

Fig. 1a & 1b. — Anteroposterior and lateral radiographs demonstrating a Salter-Harris II fracture of the distal femur with widening of the physis medially.

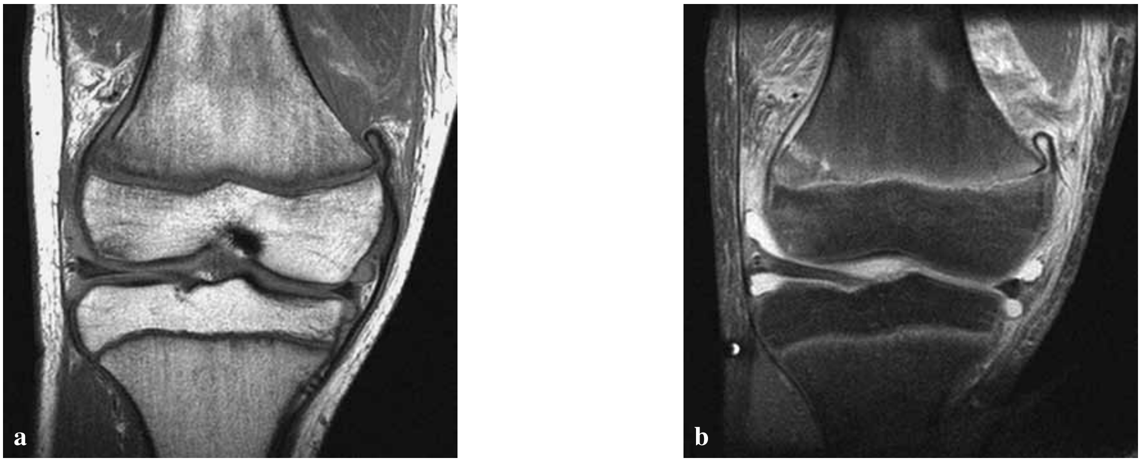

Fig. 2a & 2b. — T1 and T2 weighted coronal magnetic resonance images with entrapment of the periosteum on the medial side of the distal femoral physis.

Fig. 3. — Intra-operative photograph showing removal of the entrapped periosteum.

Fig. 4. — T2-weighted magnetic resonance image demonstrating a central osseous physeal bar.

Open reduction of the fracture was recommended to remove the interposed periosteum on the medial side, achieve anatomic reduction, and potentially reduce the risk of premature physeal arrest.

After exposure of the fracture site on the medial side, a gentle valgus stress was used to dislodge the interposed periosteum (Fig. 3). The periosteum was sutured to the proximal periosteum, a stable anatomic reduction was achieved, and a long leg cast was applied. Internal fixation with smooth pins was not used, and subsequent radiographs demonstrated no loss in reduction of the fracture. The patient began physical therapy six weeks from the initial injury. At five months follow-up, the patient had full range of motion of his left knee. Leg lengths were noted to be equal. Radiographs of the left knee demonstrated an indistinct distal femoral physis and concern for a premature physeal arrest. A MRI demonstrated a central osseous physeal bar (Fig. 4). The patient subsequently underwent a left distal femoral epiphyseodesis to complete physeal

Fig. 5a & 5b. — Anteroposterior and lateral radiographs demonstrating a Salter-Harris II fracture with widening of the distal femoral physis.

arrest of the growth plate and prevent potential angular deformity. The patient and family wished to address potential limb length discrepancy (LLD) at skeletal maturity.

Case 2

A 12+10-year-old male was struck on the lateral aspect of his right knee by an opposing player's helmet while playing football. Upon admission to the emergency department, the patient's neurovascular status was intact. Radiographs demonstrated a Salter-Harris II fracture and widening of the distal femoral physis (Fig. 5). An MRI showed entrapped periosteum on the medial side of the distal femoral physis (Fig. 6). The patient underwent an open reduction of the distal femoral physeal fracture with removal of the entrapped periosteum. A stable anatomic reduction was obtained and maintained (Fig. 7). Seven months following the injury, a subsequent MRI demonstrated greater than 50% closure of the physis. A scanogram demonstrated a LLD of 1.8 cm. A LLD of 4-5 cm

Fig. 6. — T2-weighted magnetic resonance image showing entrapped periosteum on the medial side of the distal femoral physis.

was predicted if no intervention was undertaken. An epiphyseodesis on the medial side of the right distal femoral physis to minimize angular deformity, and a contralateral epiphyseodesis of the distal

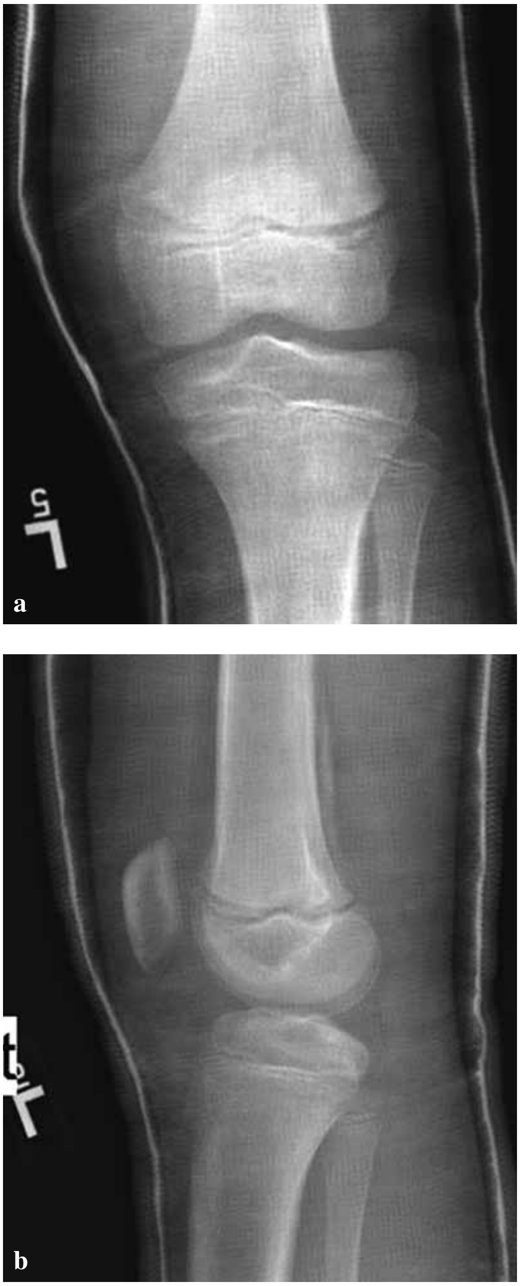

Fig. 7a & 7b. — AP and lateral radiographs noting stable anatomic reduction of the distal femoral fracture four weeks following open reduction and removal of entrapped periosteum.

femur and proximal tibia to equalize leg lengths was performed. At last follow-up, when the patient was 15+6 years of age, the LLD was one centimeter.

DISCUSSION

The risk of developing a premature physeal arrest following a distal femoral physeal fracture in a skeletally immature individual, resulting in either angular deformity or limb length discrepancy, is reported to range from 27 to 50% (*5,17,22*). Arkader *et al* (*1*) in a study of 83 fractures, recently noted premature physeal arrest in 20 patients (27%). Eleven of their patients had a significant LLD that required surgical intervention. In nine of these patients (89%), the fractures were displaced at the time of surgery.

Clinical or radiographic factors described as increasing the risk of premature growth plate arrest include the degree of fracture displacement (*1,3, 17,26*), the age of the patient at the time of injury (*10,11,22*), metaphyseal comminution (*14*), and the quality of fracture reduction (*8,11,22*). Controversy exists as to the reliability of the Salter-Harris classification of growth plate fractures in predicting future growth disturbances (*1,7,10,11,17,23,25*).

It is our belief that entrapment of the periosteum in distal femoral physeal fractures should be considered an additional risk factor for premature physeal arrest. Fractures with widening of the physis prior to reduction or irreducible fractures after attempts at closed reduction are highly suggestive of entrapment of the periosteum or other soft tissue structures at the fracture site (*9*). Removal of the entrapped periosteum to achieve an anatomic reduction may not guarantee return of normal physeal activity.

Both skeletally immature patients in these case reports had pre-operative MRI and clinical documentation of periosteal entrapment, both developed premature physeal arrest and required subsequent surgical intervention to address limb length and angular deformities. Both fractures were thought to be stable after obtaining an anatomic reduction, and stabilization of the fracture with smooth pin fixation was not used. The periosteum is strongly attached to the epiphysis and the physis at the zone of Ranvier, but relatively less strongly attached to the metaphysis (*16*). Periosteal entrapment on the tension or distraction side of the fracture, may represent a high-energy injury, stripping off the periosteal sleeve from the metaphysis (*11,22*), and become interposed into the widened fracture site prior to the physis springing back into a more normal alignment. This can result in injury to both the epiphyseal blood supply and to the physeal cartilage (germinal zone) resulting in physeal arrest despite anatomic reduction.

Entrapment of the periosteum after physeal fractures has been described at other locations. Two recent papers have discussed periosteal interposition at the distal tibial physis following Salter-Harris I or II fractures (*2,15*). Other sites of involvement include the proximal humerus, distal radius, and proximal tibia (*16,19,27*). Whan *et al* (*27*) presented MRI documentation of entrapped periosteum within the proximal tibial physis. Upon literature review, pre-operative MRI demonstrating entrapped periosteum has not been previously reported in distal femur fractures.

The role for pre-operative magnetic resonance imaging (MRI) for distal femoral fractures has yet to be defined. Close *et al* (*6*) evaluated 315 paediatric knees after traumatic injuries. Seven distal femoral physeal fractures and two proximal tibial fractures were identified, demonstrating widening of a portion of the physis with visualization of the fracture lines, and periosteal elevation in five cases. No description of periosteal entrapment was noted. Smith *et al* (*24*) evaluated the utility of early MRI (within ten days of fracture) after at risk fractures. The authors found it useful to identify trans-physeal bridging by altered Harris-Park lines suggestive of premature physeal arrest. Similarly, Havranek *et al* (*13*) used MRI to map out the size and location of trans-physeal osseous bars following premature physeal arrest to help determine appropriate treatment and pre-operative planning. Carey *et al* (*4*) evaluated 14 patients with suspected growth plate injuries within two weeks of the injury. The authors advocated the use of MRI as an important diagnostic imaging tool to assess growth plate injuries and detect occult injuries. None of these studies documented periosteal entrapment nor were these studies performed preoperatively.

The authors readily acknowledge that this preliminary report of two cases demonstrating periosteal entrapment and subsequent premature physeal arrest is not strong scientific evidence as a risk factor for further growth disturbance. Multicenter studies specifically addressing periosteal entrapment with long-term follow-up is required. The literature has suggested that soft tissue interposition should be addressed if the fracture is irreducible. It is our intent to raise awareness of periosteal entrapment in distal femoral fractures as a potential risk factor for growth plate arrest. To the best of our knowledge, MRI of periosteal entrapment at the distal femur has not been previously reported. The preoperative role of MRI in distal femoral fractures remains poorly defined. We believe that MRI should be considered in the preoperative period for fractures with physeal widening ; to evaluate for periosteal entrapment, rule out occult injury, provide additional information for pre-operative planning, and to counsel with the patient and family the risk of potential growth plate disturbance. Normal physeal growth after removing the entrapped periosteum in distal femoral physeal fractures as well remains poorly defined. Periosteal entrapment reflects a high-energy injury, similar to that previously noted in Salter-Harris II fractures with metaphyseal comminution (*14*), and may result in premature physeal arrest due to direct mechanical or indirect vascular injuries to the germinal zone of the growth plate despite achieving an anatomic reduction at the time of surgery.

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