



Case Report

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Concurrent Salter-Harris Type II Proximal Tibia Fractures Associated with Vitamin D Insufficiency



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Abstract

Background: Proximal tibia epiphysis fractures account for 1.8 to 3% of physeal injuries, 0.6% of long bones fractures in children, and 30% of partial growth plate arrest. African American children with vitamin D insufficiency (defined as serum 25OHD below than 30ng/mL) have decreased bone mineral density compared to children sufficient vitamin D levels.

Case Description: This case presents the diagnosis, treatment, and outcome of simultaneous bilateral Salter-Harris type II fractures of the proximal tibia, with concomitant fracture of the tibia tubercle in a 14-year-old African American male with insufficiency of vitamin D while running forward.

Literature Review: Bilateral Salter-Harris type II fractures have only been published by Potenza et al. [1] occurring with minor trauma. Although Schilling et al concluded that vitamin D deficiency (serum 25OHD below 20ng/mL) was unlikely to contribute to fractures in young children, data supporting an association of vitamin D deficiency and forearm fracture in African American children was reported by Ryan et al. [2], as well as hypovitaminosis D and upper extremity fractures in James et al. [3].

Clinical Relevance: Health care practitioners should carefully evaluate injuries to the proximal tibia epiphysis in late adolescence to detect missed fractures lines on radiographs. A better understanding of the anatomy of the proximal leg in children and an appreciation of the advantages and disadvantages of the available treatment modalities will aid in determining the best technique required for treatment. Health care practitioners should consider vitamin D screening in African American teenagers in order to reduce the morbidity in at-risk patients.

Introduction

physeal tibia fractures constitute 15% of epiphyseal injuries. They are the third most common fractures that affect the growth plate, following hand phalanx and distal radius fractures. These fractures predominantly occur in overweight, fast-growing males between 8-15 years of age [4-6]. Protective factors for the proximal tibia epiphysis appear to be the epiphyseal plate's irregular shape and the surrounding soft tissue (fibular head ligaments, patellar tendon, insertion of semitendinosus and medial collateral ligaments into the proximal metaphysis) [7-10]. The most commonly used classification system is that of Salter-Harris [11], being type II 37% of all proximal tibia fractures in children [1,12], resulting from severe hypertension and valgus strain due to excessive external force [9,12].

A particular flexion-type injury is described as a combination of a Salter-Harris type II fracture of the proximal tibia physis associated with a tubercle avulsion [4]. It results from vulnerability during ossification for tensile forces of the quadriceps muscle on the anterior portion of the tibia growth plate, as this begins to close asymmetrically from posterior to

anterior, transmitting the impact by the patellar tendon on the tibia tubercle [4, 11,13-16]. Simultaneous bilateral Salter-Harris type II fractures are extremely rare and only case reports about them have been published [1]; as it also are a combined fractures of the proximal tibia physis and tibia tubercle [17,13].

Although diagnosis and treatment have previously been well described [14,18,19], there have been no studies of the predisposing weakness of the growth plate that leads to simultaneous fractures without a direct trauma. Vitamin D plays an important role in the bone matrix mineralization of the growth plate cartilage through the regulation of mineral homeostasis [20]. It participates in bone mass recruitment along with a variety of factors, ranging from genetic determinants to nutritional influences [21]. It is noted to increase during times of growth spurt [20].

Certain diseases like endocrine imbalance make the epiphyseal plate more vulnerable to injury and predisposed epiphyseal separation [9]. Although the role of vitamin D in bilateral upper tibia Salter-Harris type II remains unknown, the

measurement of vitamin D is becoming more common in physeal assessment [20] and may be beneficial in the initial workup of patients with upper tibia Salter-Harris fractures. Treatment of hypovitaminosis D may facilitate postoperative healing in teenage children owing to the fact that the per pubertal adolescent period experiences an increased nutritional and metabolic demand that is secondary to the increased growth during the developmental period [20].

The association between vitamin D insufficiency and a traumatic proximal tibia fracture remains unclear and, to our knowledge, has not been previously reported. The purpose of this report is to raise awareness on the screening of vitamin D insufficiency in African American adolescents, which is one of the most prevalent deficiencies among this pediatric population, as recent studies has highlighted the importance of the effects of vitamin D on adolescent growth [3,22-25] and may be a risk factor for epiphyseal fractures without adequate trauma. This report presents a case of an overweight 14-year-old African-American boy who presented with simultaneous, bilateral,

Salter-Harris type II fractures of the proximal tibia with posterior displacement of the epiphysis with a concomitant unilateral avulsion of the tibia tubercle, occurring without a direct trauma, and vitamin D insufficiency.

Case Report

A 14-year-old African American boy, with a body mass index of 28 kg/m² was playing dodge-ball, felt a "pop" in his bilateral knees while running forward and then fell to the ground in a flexed position. physeal examination was significant for swelling of both knees and extreme tenderness over the joint line. Laboratory findings were significant for a 25-hydroxy-vitamin D value of 22ng/ml. His radiographs revealed both right and left-sided displaced and angulated mildly comminuted Salter-Harris type II fracture involving the proximal tibia, with medial and posterior displacement and angulations of the distal fragments; and fragmentation of the tibia tubercle accompanying the right side (Figure 1A & 1B). After close reduction (Figure 2A & 2B), patient was carried to the operating unit, where the left leg, initially most displaced, was treated first.

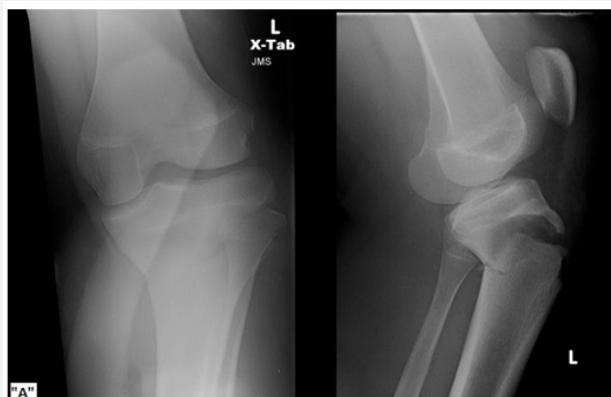


Figure1A: Preoperatively left-sided AP and Lateral radiographs of the knee joint showing medial and posterior displacement and angulation of the distal fragments and mildly comminuted Salter-Harris type II fracture of the proximal tibia with fragmentation of the tibial tubercle.



Figure1B: Preoperatively right-sided AP and Lateral radiographs of the knee joint showing medial and posterior displacement and angulation of the distal fragments and mildly comminuted Salter-Harris type II fracture of the proximal tibia.

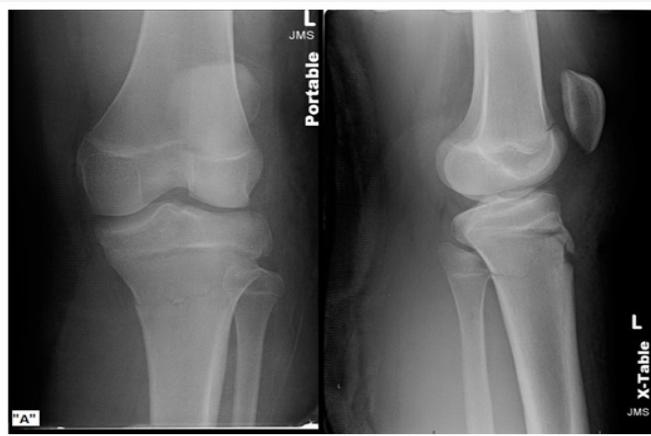


Figure 2A: Post reduction AP and lateral films showing improved alignment on the left knee joint.



Figure 2B: right knee joint.

A lateral tibia peri-articular locking plate, locking screws and bi-cortical screws were placed in the proximal fragment parallel to the joint surface reducing it to the proximal tibia. Same procedure was performed in the right side, to addition of the placement of percutaneous lag screws across the tibia tubercle apophysis. At one month follow-up radiographs showed bony alignment within normal limits without evidence of hardware

complications (Figure 3). He was seen for one postoperative visit and then lost to follow-up. Was brought back in by his parents seven months later, had not been ambulating and had been using a wheelchair since his injury. Radiographs were taken and showed healed, well anatomically reduced bilateral tibia plateau fractures (Figure 4A & 4B).

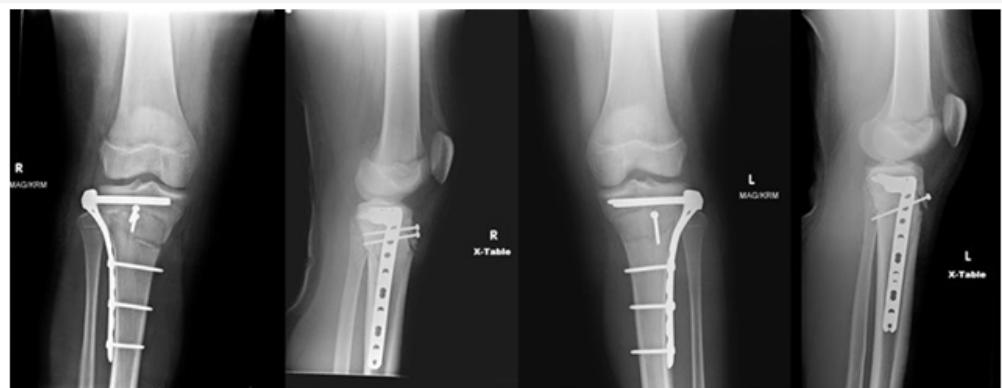


Figure 3: At one month follow-up, AP and lateral radiographs of both right and left knee joints, showing bony alignment within normal limits without evidence of hardware complications.



Figure 4A: Eight months postoperatively AP and lateral radiographs of the right knee joint.



Figure 4B: Left knee joint revealed healed and well anatomically reduced bilateral tibial plateau fractures.

Discussion

Proximal tibia epiphysis fractures are rare, accounting for <2% of lower extremity epiphyseal injuries [7,16]. Proximal tibia growth plate fractures are infrequent, with most resulting in anterior, anterolateral, and anteromedial epiphyseal

displacement relative to the metaphysis. Rarely, these injuries are caused by rapid knee flexion against the contracting quadriceps during landing. This infrequently results in a Salter-Harris type II injury, an injury that traverses the physis before exiting obliquely across a corner of the metaphysis and the most common proximal epiphyseal injury (Figure 5) [9,26].

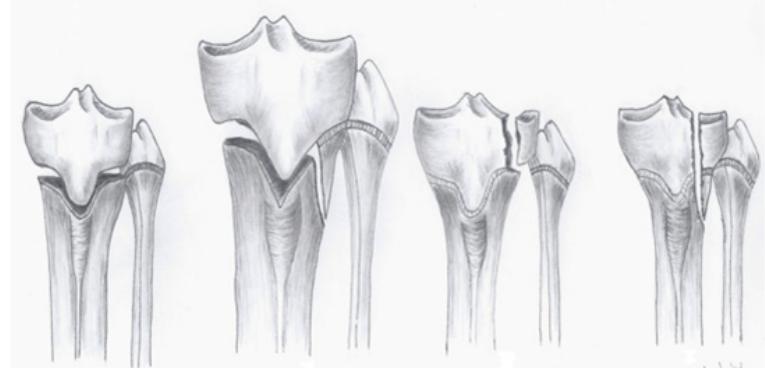


Figure 5: Proximal Tibial epiphyseal fractures classification according to Salter and Harris.

Less often, tibia tubercle injuries occur: these are nearly all described in boys aged 15 to 16 years of age with a BMI >28 and caused either by violent contraction of the quadriceps muscle (such as while jumping) or acute passive knee flexion against a contracted quadriceps muscle (while starting or landing a jump) [13,16]. Tubercle injuries present with soft tissue swelling and tenderness directly over the tubercle [14].

The normal epiphyseal plate consists of resting and proliferating cells surrounded by cartilaginous matrix; this gives strength to the epiphyseal plate, particularly resistance to shear forces. Certain diseases, such as hormonal imbalances (Kraus et al. [18]), render the epiphyseal plate more vulnerable to injury, thereby predisposing to epiphysiolysis [9]. In rats, Idelevich et al. [21] showed that calcitriol treatment augments proliferation and directly stimulates growth plate chondrocyte maturation, which later undergoes replacement with primary spongiosa [9, 21].

Although the detrimental effects of vitamin D deficiency on bone growth have been recognized for over a century, the effects of suboptimal vitamin D levels on growth plates have not been fully characterized. Vitamin D plays an important role in bone mineral density (BMD) development [20,27,28] and muscle strength; insufficiency is defined as a 25-hydroxyvitamin D level of 21 to 29ng/mL according to an Institute of Medicine 2011 report [29]. It influences skeletal integrity by maintaining calcium homeostasis in growth plate chondrocytes matrix mineralization [21,30,31] and aids in the prevention of fractures [30,31]. Sevenler et al. [32] demonstrated in mice that the growth plate mechanical response to shear loading at the micro scale is disrupted by dietary insufficiency of vitamin D. This effect combined with known changes in columnar growth rates induced by vitamin D deficiency, may be an important mechanism contributing to growth plate disorganization and weakness [32] and a predisposing factor to fractures with minor or no trauma. Williams et al. [33] reported an animal model in which the lateral region of the bovine proximal tibia physis was stronger and has a greater tangent modulus than the medial and central regions, which could explain the medial displacement of the proximal fragments in both tibias. Vitamin D insufficiency is more prevalent among African Americans adolescents [23,24], they are more likely than white adolescents to be overweight or obese. In addition, darker skin pigmentation is a risk factor for vitamin D deficiency [2,22,24,25].

Ryan et al reported that both lower BMD and vitamin D deficiency ($\leq 20\text{ng/ml}$) increase the odds of forearm fracture in African American children [2]. In a study of 181 children with upper extremity fractures, James et al found that 41% had insufficient vitamin D levels, and among these children, African American children were more likely to have insufficient or deficient vitamin D levels [3]. Previous reports have noted bilateral Salter-Harris type II occurring either consecutively by Ozokyay et al. [22] with previous osteochondrosis of the anterior tibia apophysis by Merloz et al. [22] or simultaneously

resulting from landing from a high jump by Potenza et al. [22]. There are no combined bilateral fractures of the proximal tibia physis and tibia tubercle reported, the few instances reported on the literature have been unilateral [13].

The treatment of proximal tibia physeal fractures follows the general principles of other Salter-Harris physeal fractures [11,34]. A common theme throughout the literature is the difficulty in maintaining the reduction with cast alone, especially with posterior displacement of the tibia [35]. Generally, the results have been satisfactory, although in a study by Shelton et al. [12] type II displaced fractures treated by close reduction and immobilization all suffered from growth discrepancy [12]. In order to prevent angular and longitudinal deformities open reduction and internal fixation is recommended. Fracture of the tibia without concomitant fractures of the fibula, as seen in this case, can lead to various malangulation [36].

To prevent the valgus deformity, well performed reduction has to be done, and this has to be accomplished by not leaving interfragmentary medial space [37-40]. In our case the proximal tibia physeal injuries presented with posterior displacement of the epiphysis. There is no clinical and radiographical history of previous trauma, no Osgood-Schlatter disease, and no landing nor attempting to jump as mechanism of injury. These simultaneous fractures resulted while running, with no direct trauma, suggesting an associate deficit at physeal closure predisposing to the combined bilateral physeal/apophyseal injuries, raising the index of suspicion for bone weakness which makes this case unique.

Because there is a high prevalence of vitamin D insufficiency among African American children and known associated risks of fracture and decreased BMD one may conclude that in deficiency states upper tibia physeal flexion-avulsion injuries may also occur. Although only one patient is described here we suggest considering the possibility that children presenting with a traumatic epiphyseal fractures might have an underlying disorder. Additional research studies analyzing the relationship between upper tibia Salter-Harris fractures and hypovitaminosis D are necessary to infer any causative relationship, and to warrant the use of 25-hydroxyvitamin D level as a screening tool to predict risk of physeal fractures in African American children. The outcome of the patient reported here at 8-months follow-up was excellent, with no malunion or nonunion, no angular deformity, and no leg discrepancy.

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