A Subtrochanteric Femoral Stress Fracture following Bisphosphonate Treatment in an Adolescent Girl

Alison M. Boyce\textsuperscript{a,c} Michael T. Collins\textsuperscript{a} Laura L. Tosi\textsuperscript{b} Rachel I. Gafni\textsuperscript{a}

\textsuperscript{a}Section on Skeletal Disorders and Mineral Homeostasis, Craniofacial and Skeletal Diseases Branch, NIDCR, NIH, Bethesda, Md., and \textsuperscript{b}Bone Health Program, Division of Orthopaedics and Sports Medicine and \textsuperscript{c}Division of Endocrinology and Diabetes, Children’s National Health System, Washington, D.C., USA

\textbf{Abstract}

Atypical subtrochanteric and diaphyseal femoral fractures (AFFs) have emerged as a potential complication of bisphosphonate treatment in adults. Despite increasing off-label use of bisphosphonates in children and adolescents for a variety of skeletal disorders, there have been no reports of AFFs in children or adolescents outside of the osteogenesis imperfecta population. We present the case of a 16-year-old girl who developed a subtrochanteric femoral stress fracture following pamidronate treatment for idiopathic juvenile osteoporosis.

\textbf{Introduction}

Over the past decade, concerns have emerged regarding an association between long-term bisphosphonate use and an increased risk of atypical subtrochanteric and
diaphyseal femoral fractures (AFFs) in adults [1]. In contrast to typical hip fractures, which are generally traumatic and occur in the femoral neck, trochanteric and intertrochanteric AFFs affect the subtrochanteric or femoral shaft regions and arise spontaneously or with low-energy insult [2]. Bisphosphonates are increasingly used to treat disorders of low bone mineral density (BMD) in children and adolescents [3]; however, the long-term effects of bone turnover suppression on the growing skeleton are incompletely understood. Case series of children with osteogenesis imperfecta (OI), a disorder of bone fragility due to abnormalities in type I collagen, report a potential association between bisphosphonate treatment and proximal femoral fractures [4–6]. To date, there have been no reports of AFFs in children or adolescents without primary collagen defects. We present the case of an adolescent girl with idiopathic juvenile osteoporosis who developed a subtrochanteric femoral stress fracture following bisphosphonate therapy.

**Case Description**

An 11-year-old girl presented with a 1-year history of back pain and height loss due to multiple thoracic vertebral compression fractures (fig. 1A, B). A dual-energy X-ray absorptiometry scan showed low BMD with a lumbar spine Z-score of −3.9 and a total body less head Z-score of −2.0. An extensive workup, including a vertebral biopsy and testing for COL1A1/1A2 mutations did not reveal an etiology for her low BMD. She was diagnosed with idiopathic juvenile osteoporosis and treated with intravenous pamidronate starting at the age of 12. She was initially started on a regimen of 1 mg/kg given over 3 consecutive days at 4-month intervals, and after 2 doses, she was changed to a regimen of 1 mg/kg given as a single infusion at 3-month intervals. Over a 2-year treatment period, she received a total dose of 11 mg/kg. During the treatment period, the patient had partial reconstitution of her vertebral bodies and no additional fractures. Alkaline phosphatase levels were monitored prior to each infusion and ranged from 185 U/l (Z-score –1.51) at the start of pamidronate to 131 U/l (Z-score –1.38) at completion of the treatment. At pamidronate discontinuation at the age of 14 years, her lumbar spine Z-score had improved to −1.6, and the total body less head Z-score to −0.6 (fig. 1C). Pubertal onset and progression were normal, including menarche at the age of 14 years, and completion of linear growth at the age of 15 years.

![Fig. 1. Pre- and post-treatment clinical images. A The patient’s growth curve showing growth deceleration between the ages of 10 and 12 years, consistent with vertebral height loss secondary to thoracic compression fractures. The height percentile improved after 2 years of pamidronate therapy. B Lateral spine radiograph at the age of 10 years showing diffuse osteopenia and a T6 vertebral compression fracture (black arrow). C Dual-energy X-ray absorptiometry of the lumbar spine showing a progressive increase in the BMD Z-score during pamidronate treatment between the ages of 12 and 14 years.](image-url)
At the age of 16 years, the patient presented with a 3-week history of left-thigh pain. Several weeks before, she had joined a cross-country team after many years of low sports activity and was running 3–4 miles per day at the time of presentation. Radiographs showed diffuse cortical thickening of the bilateral femoral diaphyses and a localized periosteal reaction at the medial cortex of the proximal left femur (fig. 2A). A technetium-99 bone scan showed focal tracer uptake in the medial aspect of the left proximal femur (white arrow) and mild uptake along the right tibial and tarsal area (white arrowheads).

**Discussion**

This adolescent’s presentation with a femoral stress fracture 2 years after completing a course of high-dose pamidronate treatment shares several features in common with AFFs, including the subtrochanteric location, localized periosteal reaction, and generalized cortical thickening of the femoral diaphysis. Her recent increase in physical activity following a period of deconditioning is a known risk factor for stress fractures [7], which is further supported by her concomitant tibial injury. Although stress fractures are common overuse injuries in adolescents, femoral diaphyseal stress fractures are relatively uncommon in this population [8, 9], raising concern for a possible association with pamidronate treatment. The pathogenesis of AFFs is not well understood; however, evidence suggests that, similar to typical stress fractures, they may be related to skeletal damage from repetitive loading. This is supported by two case reports describing the evolution of AFFs on retrospective review of serial dual-energy X-ray absorptiometry scans [10, 11]. In both cases, periosteal callus formation occurred prior to the development of a transverse cortical fracture, a pattern characteristic of stress fractures. This supports the current hypothesis that AFFs arise when reduction in bone remodeling inhibits the repair of microfractures that occur from repetitive loading, and that integration of these microfractures into a single cortical defect promotes formation of a transverse fracture. In keeping with this hypothesis, the American Society for Bone and Mineral Research (ASBMR) Task Force has recently classified AFFs as stress injuries [2]. It is possible that the higher doses of pamidronate used in the treatment of this patient, particularly early in the treatment course, placed her at higher risk for bone turnover suppression. Alkaline phosphatase levels remained in the lower portion of the normal range during the treatment period; however, a post-treatment level at the time of her fracture presentation was frankly low, further supporting a potential pamidronate-related decrease in bone turnover. This patient’s protracted clinical course with delayed healing is also typical of AFFs, potentially related to the inhibition of bone modeling processes involved in fracture repair [2].

The unusual location of this patient’s femoral fracture raises particular concern about a possible contributory effect of bisphosphonate treatment. This is supported by recent evidence in patients with OI. Nicolaou et al. [5] reported a retrospective review of femoral fracture location in 176 bisphosphonate-treated OI patients compared to historical controls. In this series, 14/16 femoral frac-

---

**Fig. 2.** A Pelvic radiograph at the age of 16 years showing a periosteal reaction at the medial cortex of the left proximal femur (white arrow) and diffusely thickened diaphyseal cortices (asterisks). Parallel sclerotic bands are visible along the curve of the iliac crest, marking the pamidronate infusions (white arrowheads). B Technetium-99 bone scintigraphy showing focal tracer uptake in the medial aspect of the left proximal femur (white arrow) and mild uptake along the right tibial and tarsal area (white arrowheads).
tured in the bisphosphonate-treated cohort occurred within the subtrochanteric location, in contrast to a widespread fracture pattern in the historical controls. Hegazy et al. [4] reported a series of 6 bisphosphonate-treated children with OI who sustained minimally traumatic subtrochanteric and diaphyseal femoral fractures over preexisting intramedullary rods, and Vasanwala et al. [6] similarly reported an adolescent OI patient with recurrent, atraumatic femoral fractures following bisphosphonate treatment. The contribution of the underlying collagen defect in the development of femoral fractures in these series is unknown, and to our knowledge, there have been no reports of subtrochanteric femoral fractures in non-OI children treated with bisphosphonates.

Several features of this patient’s fracture call into question the contribution of bisphosphonate treatment. Although causality between bisphosphonate use and AFFs in adults has not been definitively established, the number of high-quality epidemiologic studies demonstrating an association continues to mount. In particular, several studies have demonstrated a positive correlation between treatment duration and AFF risk, as well as a decline in risk with bisphosphonate discontinuation [12–14]. This patient’s fracture occurred 2 years after pamidronate discontinuation, at which time her risk of bisphosphonate-associated AFF should theoretically have been declining. Unlike bisphosphonate-associated AFFs in adults, which typically develop on the lateral tensile cortical surface [2], this patient’s stress fracture occurred at the medial cortex. The lack of a transverse fracture line is also inconsistent with ASBMR 2013 Task Force Case Definition of AFFs, although this may have been related to early diagnosis and aggressive intervention preventing her fracture from progressing. Thus, while suggestive, the contribution of bisphosphonate treatment to the development of this patient’s stress fracture is not known. Nevertheless, clinicians should evaluate thigh pain in adolescents with a history of bisphosphonate treatment, particularly in those with low bone turnover and risk factors for stress injuries, and should include AFFs and other femoral stress fractures in the differential diagnosis.

Acknowledgements

This research was supported by the Bone Health Program of the Division of Orthopaedics and Sports Medicine, Children’s National Health System, and the Intramural Research Program of the NIDCR, NIH.

Disclosure Statement

The authors have nothing to disclose.

References


