

## Stress fractures in children: a review of 37 cases

Nikolaos G. Papadimitriou · John Christophorides ·  
Angeliki Papadimitriou · Theodoros A. Beslikas ·  
Thrasos N. Ventouris · Basilios A. Goulios

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**Abstract** Stress fractures are uncommon injury in young active children and may present diagnostic dilemmas. They may have features in common with situations like infection or tumor and early suspicion of them is critical in order to eliminate the need for costly or invasive investigations. We retrospectively reviewed 37 stress fractures in 37 children from June 1980 to December 2005. We reviewed stress fractures on the basis of location, age and treatment options. It discusses the most recent literature describing their presentations, and suggested criteria for avoiding complications. The most common site was the tibia with 18 cases (49%) followed by the fibula (19%). Two were found to involve the distal femur shaft and two the femur neck which one was a tension and one a compression type. Three fractures were found to involve the inferior pubic ramus. Two children had a transverse patella fracture and three of the metatarsals. The most common complaint was pain with physical activity which in rest relieves. The earliest radiographic findings included periosteal callus formation that rapidly consolidated to new bone on serial studies. All stress fractures healed without complications. A thorough history and plain radiographs can differentiate stress fractures from infection or neoplasm in the skeletally immature.

**Keywords** Femur · Femur neck · Tibia · Pubic ramus · Patella · Fibula · Skeletally immature · Stress fracture · Children

### Fractures de stress chez l'enfant

**Résumé** Les fractures de stress ne sont pas habituelles chez des enfants jeunes et actifs et peuvent poser des dilemmes diagnostiques. Elles peuvent présenter des caractéristiques communes avec les infections ou les lésions tumorales et la suspicion du diagnostic est essentielle si l'on veut éviter des examens complémentaires coûteux et inutiles. Nous avons étudié rétrospectivement 37 fractures de stress survenues chez 37 enfants entre juin 1980 et décembre 2005, sur la base de la localisation, de l'âge et des options thérapeutiques. Nous discutons ensuite de la littérature la plus récente pour décrire leurs tableaux cliniques et suggérer la façon d'éviter leurs complications. La localisation la plus habituelle est le tibia avec 18 cas (49%), suivie par celle de la fibula (19%). Deux cas furent trouvés localisés à la partie distale de la diaphyse fémorale et deux autres au col du fémur, l'un de type fracture en traction et l'autre de type fracture en compression. Trois furent notés à la branche inférieure du pubis. Deux enfants avaient une fracture transversale de la rotule et trois autres des métatarsiens. La plainte la plus fréquente consistait en douleurs aux efforts disparaissant au repos. Les signes radiologiques les plus précoces consistaient en cals périostés se transformant ensuite rapidement en os néoformé. Une étude anamnétique minutieuse et des radiographies standard permettent de distinguer la fracture de stress de l'infection ou de l'ostéosarcome chez l'enfant au squelette encore immature.

N. G. Papadimitriou · J. Christophorides · A. Papadimitriou ·  
T. A. Beslikas · T. N. Ventouris · B. A. Goulios  
2nd Orthopaedic Department,  
Aristotle University of Thessaloniki,  
G. Gennimatas hospital, 41 Ethikis Aminis str.,  
54635 Thessaloniki, Greece

N. G. Papadimitriou (✉)  
Mantzaridi 3 N 751 Panorama,  
55236 Thessaloniki, Greece  
e-mail: papadig@hotmail.com

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## Introduction

Stress fractures in adults are relatively common in athletes and military recruits but also among otherwise healthy people who have recently started a new or an intensive physical activity with no injury.

Although in international literature plenty have been written about stress fracture in adults; little or sporadic case reports are presented for children. The largest series of stress fractures concerning children have been published by Devas [1] with 35 cases in 1963 and by Walker [2] with 32 cases in 1996.

An increasing participation in sports has witnessed the last decade especially by young athletes. The type of stress fracture and the site at which it occurs in bone varies with age and activity.

Stress fractures at pediatric population are more liable to be mistaken as neoplasm or infection because of rapid periosteal response and abundant callus formation at the site of the injury which can lead inadvertently to expensive imaging studies and unnecessary surgical procedures.

A delay from symptom onset to diagnosis is common. It is important for clinicians and training coaches

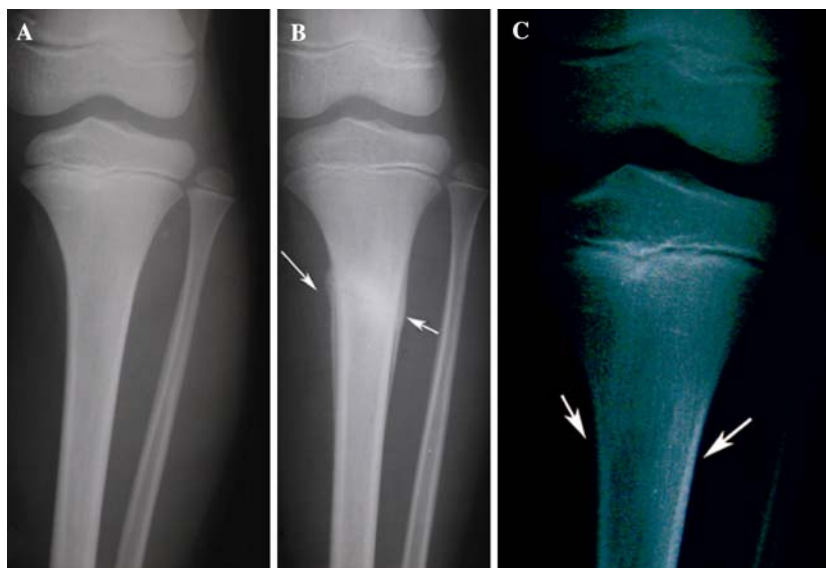
to be familiar with this type of overuse injury thus avoiding missing the diagnosis.

## Patients and methods

We retrospectively reviewed 37 stress fractures in 37 skeletally immature patients from 1980 to 2005. The average age of patients was 8.9 years ranging from 2 to 15 years. Twenty patients (54%) were male and 17 female. Lesions corresponding to spondylolysis were not included in the review. Associated medical conditions were not found in our patients. The parameters reviewed were patient age, fracture location and treatment.

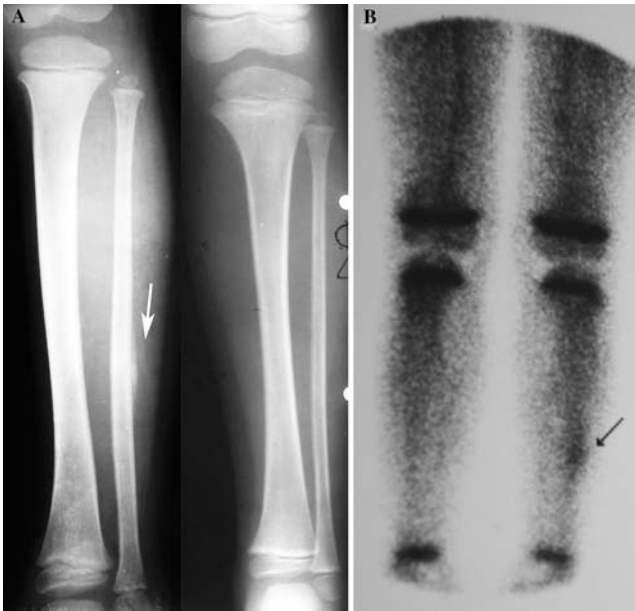
## Results

A total of 37 stress fractures were seen. The most prevalent site was the proximal tibia—49% of fractures with 18 fractures (Fig. 1). The second most commonly affected bone was found to be fibula—19% of fractures with seven fractures (Fig. 2). Three fractures were found to involve the inferior pubic ramus, two the patella, one the 3rd metatarsal and one the 5th metatarsal. Two were found to involve the distal femur shaft and two the femur neck which one was a tension and one a compression type.



**Fig. 1** A 4-year-old boy presented to his primary-care physician because of vague pain below the left knee for several weeks duration. **a** Initial AP radiograph of left upper tibia was not diagnostic and the patient dismissed with the diagnosis pes anserinus tendonitis. **b** After 15 days the patient continued to complain of pain in the same area. New AP radiograph demonstrated the fracture

line (*white arrows*) and concomitant periosteal thickening of the cortex of the upper tibia. The diagnosis was consistent with tibia stress fracture. **c** Initial AP radiograph (**a**) was thought to be negative for fracture. Fracture line became visible in retrospect after digital image processing—contrast and brightness adjustments (*white arrow*)



**Fig. 2** A 4-year-old boy presented with vague complain of the left shin. **a** Initial anteroposterior radiographs of the left shin were inconclusive. **b** He was admitted to the hospital and  $^{99m}\text{Tc}$  bone scintigraphy suggested a focal uptake in the middle third of the left fibula. **c** Symptoms resolved and periosteal reaction is noted after 3 weeks. Fibular stress fracture was diagnosed

Tibia has been found to be fractured more frequent in the proximal site (72%) and never to the distal site. Seventy-two percent of fractures in tibia have been found at the posterior medial site of the bone. This pattern was reversed for the fibula where we have never found a single fracture proximal. The most prevalent side of fractures in pediatric population was the left side—84% of them affected the left side and 16% the right.

The most common presenting complaint was the spontaneous onset of pain after activities, which diminished during the night and relieved by rest. The average time between symptom onset and the diagnosis of stress fracture was 25 days.

The roentgenographic appearance of callus was highly suggestive mainly of sarcomas in 32% of our patients and underwent biopsy in order to be excluded.

The most common treatment modality in this series of patients was cast immobilization. No complications have been noted and all fractures healed uneventful.

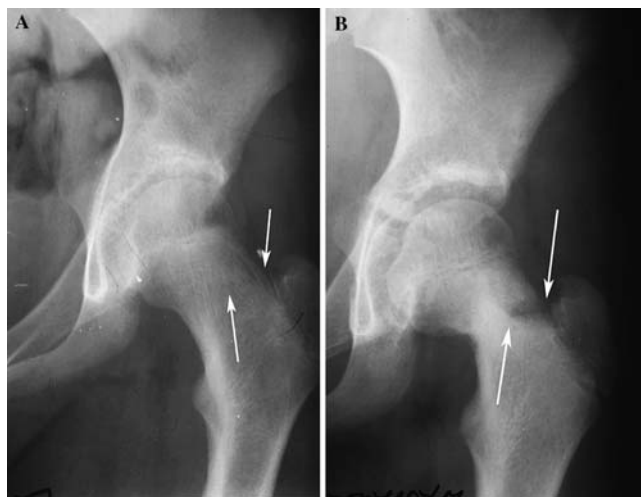
A very active 7-year-old boy presented with anterior knee pain. Initially X-rays were nonsignificant and the patient was advised to rest. The child for a month desisted from activities but the symptoms persisted. New radiological examination showed an undisplaced transverse stress fracture of the patella (Fig. 3). After immobilization in a plaster cylinder cast from groin to ankle for 6 weeks, he returned to normal activity in 2 months.



**Fig. 3** Lateral knee radiographs of an undisplaced transverse stress fracture of the patella (white arrow)

A 10-year-old healthy girl (case 11) had increasing light hip pain left for 2 months after being very active on school athletic recreational activities. The pain often was not severe enough to deter her from activities and for the last 2 weeks she keenly attended ballet dance lessons. She presented to the emergency department complaining of limp and light pain in the left groin, which was increased over the last week. On physical examination the child presented with an antalgic gait left and slight painful limitation of hip motion. Initial radiographs have been thought to be inconclusive and the patient refused to be admitted in the hospital for further evaluation (Fig. 4a). After a week she suffered a minor fall down in her house and she presented again to our clinics emergencies. New radiographs have been taken which revealed a displaced stress fracture on the tension side of the femoral neck. After more careful examination of the initial radiographs and the advent of digital imaging processing the fracture line was revealed (Fig. 4b). Bed rest in adduction and internal rotation was instituted for 4 weeks and the fracture healed after 10 weeks in a hip spica cast.

A 5-year-old girl (case 18) had a progressive limp for a month. She was overweight but she had increased her activity by school entrance and outdoor activities as her family moved to reside in a rural area. The initial diagnosis on admission was irritable hip. Radiographs



**Fig. 4** A 10-year-old healthy girl presented complaining of groin pain for the last 2 months. **a** Initial radiographs have been overlooked. **b** After a minor fall a displaced femoral neck stress fracture at the tension side appeared. Reexamination of the initial radiographs (**a**) revealed the fracture line which is hardly seen (white arrow)

revealed a stress fracture on the compression side of the femoral neck. She still had pain, and the fracture was still present on radiograph after 6 weeks of crutch walking without bearing weight on the limb. The fracture healed after 12 weeks' treatment in a hip spica cast.

## Discussion

The number of musculoskeletal overuse injuries in children is on the rise as children's participation in sports increases. The general symptoms and signs are usually not conclusive. Pain is not severe and young patients rarely are brought early for advice. In initial radiographs nothing is clearly seen and careful clinical examination reveals tenderness but not swelling around the region of fracture. General malaise and even slight irregular fever could be sometimes concomitant signs in pediatric patients with stress fracture. Usually bed rest is followed by a rapid cessation of symptoms.

The diagnosis of stress fracture in pediatric patient is difficult and often the physician can be misled. We have had frequent delay to set final diagnosis of stress fracture from onset of symptoms. The delay time was as long as 2 months which does not differ from what other authors have reported [2]. Missing a stress fracture in lower extremity especially in long bones could be deleterious due to the risk of displacement [3]. Initial radiographic findings are often subtle or confusing.

The earliest radiographic sign usually after a week is the presence of new callus formation by the periosteum giving the appearance of "layers of eggs shell" especially if the diaphysis of bone is involved. The fracture itself usually cannot be visualized by exuberant callus that expense up and down the shaft. The initial fracture at its onset is minute in size and as loading continues it progresses sufficiently to show a faint hair-line crack. The X-ray beam must pass tangentially to the affected cortical surface because it is only one small area that is affected. This is the reason why initial radiographs are not conclusive. Attempts have been made to use other imaging modalities such as computed tomography (CT) scan and magnetic resonance imaging (MRI) to help alleviate confusion. However, the results are sometimes conflicting or do not help with the diagnosis [4] to confirm the presence of stress fracture. Bone scintigraphy is recommended for the diagnosis of stress fractures in the early stage. Although the sensitivity of bone scans is high for stress fractures bone, scintigraphic findings of stress reaction are nonspecific [5]. We believe that we have gained much help in our study by evaluating in retrospect digitally processed initial radiographs. Early hairline fracture line normally could not be seen in initial, conventional X-ray films (Fig. 1a). After converting them to digital images and processing with appropriate digital imaging software, the fracture line will be visible (Fig. 1c). We believe that this method is a useful modality of disclosure of the fracture line and has aided us in accurate diagnosis.

Although we have followed the "wait-and-see" approach, in 32% of our pediatric patients deemed to undergo biopsy because the roentgenographic appearance of callus was highly suggestive mainly of sarcomas. Fifty-three percent of fractured tibias and 29% fracture fibulas underwent biopsy. Biopsy can be sometimes useful to exclude malignancy but is not panacea. Half of our patients who underwent biopsy had inconclusive results. The decision to perform a biopsy must not be taken lightly because it may be difficult to distinguish histologically [6] active fracture callus from osteosarcoma.

Tibia was the most common site (49%) for stress fractures in our pediatric population. Eighty-two percent ( $n = 14$ ) of tibia fractures involved the proximal and only 18% ( $n = 4$ ) the middle of the tibia shaft. We have never seen stress fracture of the tibia distally in children and we have not found ever to be reported in literature for pediatric population. Tibia shaft stress fractures are uncommon in the pediatric population and only eight cases have been reported [1, 7–9]. In three cases, nonunion [7] has been noted in contrast to

our series in which all healed uneventfully, and this is probably ascribed to that all patients have been treated with long-leg walking cast. The most commonly involved cortex of the shaft of the tibia was the posteromedial cortex and only four fractures were found in the anterolateral cortex. In adults, the proximal tibia stress fracture described invariably involves the antero-medial metaphysis [10]. It seems that in skeletally immature population the location of tibia stress fracture pattern is different.

Muscle fatigue alters the distribution of strain within the bone, contributing to the development of stress fractures [11]. But it seems that certain group of muscles which are dedicated to withstand repetitive stresses are fatigued so the strain is no longer absorbed by the muscle but from bone, which leads over time to complete bone exhaustion and mechanical failure. Bone is not physiologically resistant to strains which are exerted vertically. The different site of cortex involvement between children and adults of stress fracture in tibia may represent fatigue of different group of muscles during exercise. The extensors of the leg are attached in anteromedial site of the tibia, perhaps in adults this muscle group is more easily fatigued in contrast to the children whom flexors are prone to fatigue more easily. This is supported by the finding that in 60% of injured adult runners, functional over pronation [12] of gastrocnemius and soleus muscles was recorded. These muscles provide greater torque output to plantar flexion than do the deep plantar flexors. In addition, invasive electromyography recordings [13] suggested that these muscles were affected in runners with posteromedial stress fractures. The theory of fatiguing of certain group of muscles could be also supported by the fact that we have never found stress fracture distally of the tibia as well as proximally to fibula. In conclusion, in skeletally immature patients the location of fracture might be an indicative of a stress fracture and this could help to exclude other diagnosis.

Fibula has been the second most frequent affected (21%) site in skeletally immature patients (Fig. 2). Because of the very rapid periosteal new-bone response, the diagnosis sometimes is puzzling at the pediatric population and differential diagnosis should rule out osteoid osteoma, acute osteomyelitis, chronic sclerosing osteomyelitis, osteogenic sarcoma, Ewing's sarcoma and acute leukemia.

Three patients were diagnosed with inferior pubic stress fracture (Fig. 5). History taking revealed that two of them were karate athletes. We presume that certain actions during training like the tackle hit which demands repetitive action of adductor muscles which are inserted at the pubic ramus, could be inculcated. In



**Fig. 5** A 9-year-old girl presented with left hip pain. Three weeks after initial examination, stress fracture of the left inferior pubic ramus formation was revealed

addition, the increase in loading around the inferior pubic ramus by over striding [14] accompanied by high-impact activities may be implicating mechanism. We offered no treatment other than reassurance and confinement of activity. Certain athletic activities must be modified to aware gymnasts in order to avoid the over-use of adductor muscles in skeletally immature individuals. Stress fracture in the inferior pubic ramus can be confused with other conditions like irritable hip, Perthes, slipped upper femoral epiphysis, osteomyelitis and osteitis pubis hernia. The presenting symptom is chronic groin pain accompanied by antalgic gait. Tenderness over inferior pubic ramus or at the insertion pain on resisted adduction and external rotation of the hip may help differentiate from these conditions.

Patella stress fracture is very rare. We have found only two cases in the world English literature, reported to be transverse stress fractures of patella [15] in a child as in our case (Fig. 3). The distinction between a stress fracture, bipartite patella, Sinding–Larsen–Johansson syndrome and osteochondritis dissecans of the patella remains clinically difficult. Usually the line of a stress fracture passes horizontally through the patella while that of a synchondrosis of a bipartite patella runs more obliquely.

Femoral shaft stress fracture is very uncommon in children—only seven cases of diaphysis have been reported [16] in children. Pain and an antalgic gait are the most common complaints. Pain may be abrupt in onset or have an insidious presentation. Its danger lies that it can be converted to complete fractures with displacement [17], this can be prevented if diagnosed in time. The differential diagnosis includes osteosarcoma, eosinophilic granuloma, osteomyelitis and Ewing's sarcoma.

Femoral neck fatigue fractures in children with open physes are very rare. A comprehensive review of the English language literature identified only 15 cases previously reported [18, 19]. We presented two additional cases, one in a 10-year-old girl who was active ballet dancer and one in a 5-year-old boy who was an active karate student, both of them presenting with pain in the left groin, of 1 month duration and without evidence of previous injury. According to the classification of Devas [20], one case was a tension type femoral neck stress fractures and one of compression type.

Both of them recall certain repetitive activities, right leg rising during karate fighting and splits during dance lessons. According to biomechanics, tension stresses and strains are exerted in the superior aspect of the femoral neck, this is counteracted by contraction of the abductor muscles producing a compensatory compressive strain on the superior aspect [21] of the femoral neck. If the gluteus medius muscle is fatigued, this neutralizing effect is minimized and the superior aspect of the femoral neck is exposed to tensile strains, which can lead to fatigue of bone structure and ultimately to stress fracture. Perhaps certain athletic activities in skeletally immature individuals which involve overuse and fatigue of the hip abductors should be avoided. Femoral neck fractures have increased morbidity because of the high risk of displacement, especially the tension type progress to complete fracture when proper treatment is not instituted. The clinical presentation initially is usually mild and can mimic transient synovitis, pre-slipped capital femur epiphysis, avulsion injuries of the pelvis muscle strains and osteoid osteoma. A high index of clinical suspicion is required to not miss the diagnosis.

In 82% of patients with stress fracture the affected side was the left. Evidence of predilection of sides was also concluded from the observation of a predominance of injuries in the dominant push-off/landing leg [22] in adult athletes. Anterior stress fractures [23] of the tibia occur mainly in the push-off/landing leg in athletes in contrast to the usual posteromedial side. We presume that the prevalence of fracture to the left side is also related to the push off/landing mechanism.

Devas [24] reported two humerus stress fractures which were related to cricket play and three stress fractures which were seen in the radius. Walker also reported [2] one humerus stress fracture involved in the proximal humeral metaphysis. They were associated with upper limb-dominated sports such as tennis and swimming and those involving throwing. In our series we have not seen stress fracture in upper extremity probably because upper extremity stress fracture is not so disabling to the child compared to the lower

extremity stress fracture in which weight bearing is implicated and thus the mild clinical presentation allows them to progress sooner to complete fracture after continuing activities and they presented in emergencies' as traumatic complete fractures.

All patients treated conservatively and all fractures healed uneventfully. We have had no complications like nonunion because we have treated most of the patients with cast. We do not agree that only bed rest and abstinence from strenuous physical activity or the use only of crutches in order to avoid weight bearing suffices as treatment for stress fractures of lower extremity. Femoral neck stress fracture especially the tension type had a high tendency for displacement and can be initially easily overlooked (Fig. 4), both of our patients were initially treated with bed rest. At the follow-up radiographs revealed some displacement and subsequently were placed in a spica cast followed by no weight bearing. Both healed uneventfully at 12 weeks.

## Conclusion

Stress fractures in children may present diagnostic difficulty. Symptoms may be vague, the most common constant complain is pain of the affected region which is relieved by rest and usually no history of high energy traumatic injury can be uncovered. Stress fractures usually present without radiographic evidence on initial plain films. A serial radiograph taken during a period of several weeks to look for evidence of callus formation is an adequate approach to diagnose and treat stress fractures. Biopsy should be avoided unless there is a clear suggestion of bone destruction due to malignancy or infection or if healing radiographically is not taking place. However, parents are usually aware and apprehensive and the surgeon should convince them to accept a wait-and-see approach for treatment of their young child. Serial radiographs are useful in documenting progressive fracture healing.

From history taking in the present study also we have identified possibly precipitating factors, which may lead to stress fracture in children such as abrupt increase in exercise, excessive body load, poor equipment, and training errors, lack of an off season, an increased pressure to perform outstanding by parents and teachers and a lack of training in sport-specific surfaces and technique.

Stress fractures in children are most prevalent in the lower extremities. The differential diagnosis between stress fracture and other conditions like osteomyelitis, arthritis whether rheumatoid or infective

or other overuse injuries can be difficult. The initial diagnosis of stress fracture should always be presumed until a complete X-ray series documents the absence of fracture. The diagnosis of stress fracture is dependent on understanding of the history and clinical examination and not expecting early radiological confirmation. Serial plain radiographs taken in patients with stress fractures show periosteal new bone formation in the late phase. The speed of progress of periosteal reaction and callus formation in a stress fracture in a child often dispels any doubt even before biopsy can be arranged. Accurate diagnosis, as expeditiously as possible, is essential soon after the onset of pain. The advent of digitally enhanced imaging seems to provide encouraging results by earlier identification of fracture line and thus avoiding cumbersome over investigation.

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