Stress Fractures: Diagnosis and Management in the Primary Care Setting

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KEYWORDS

- Stress reaction • Low-risk stress fractures
- High-risk stress fractures

Stress fracture represents an overuse injury of the bone, and is one stage on a continuum of stress injury of the bone.[1–7] Stress injury of bone can be either a fatigue reaction (or fracture) or insufficiency reaction (or fracture). Fatigue fracture results from cumulative microfractures because of excessive repetitive strain to a structurally normal bone.[7] Insufficiency fracture can result from normal stress to a structurally abnormal bone.[7] In otherwise healthy adolescent athletes, stress injury to the bone is typically a fatigue reaction or fracture. Individuals with disorders that affect bone structure, such as metabolic bone disease or osteoporosis, are at risk for insufficiency fracture.

Repetitive, excessive stress results in microfractures within the bone.[5–7] This often occurs within 6 to 8 weeks of rapid increase in physical activity, not allowing sufficient time for bone remodeling and adaptation to stress. Continued stress to the bone can lead to propagation of microfracture and eventual macrofracture. The pathogenesis of stress injury to the bone is multifactorial (**Table 1**).[7–42]

EPIDEMIOLOGY

Snyder and colleagues[43] extensively reviewed epidemiologic studies on stress fractures in athletes. It is difficult to generalize data from different studies because of methodological differences among them. Factors that influence the acquisition, results, and interpretation of data include differences in definition of injury exposure, study designs, definition of injury, and accuracy and method of diagnosis (clinical, radiological). Given these limitations, several conclusions are drawn.[43]

Stress fractures affect 1.0% to 2.6% of college athletes.[44–46] Of the recreational or competitive athletes who visit a sports medicine or orthopedic clinic, 0.5% to

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Table 1
Factors associated with increased risk for stress injury of the bone

Training related	High training volume, rapid increase in training volume
Footwear	Poor shock absorption, old shoes (more than 6 mo old), poor shoe-fit (especially in women)
Training surface	Uneven running surface, hard surface (equivocal evidence)
Gender	Female gender, may be secondary to other factors such as hormonal and nutritional
Race	Higher in white and Asian women than in African American women
Fitness level	Poor muscle strength and endurance
Bone mineral density	Low bone mineral density
Bone geometry	Reduced bone cross-sectional areas and bone resistance to bending
Anatomic	Equivocal evidence for rigid pes cavus, leg-length discrepancy, genu valgus, and increased Q angle
Hormonal	Hypoestrogenic states in female athletes, delayed menarche, amenorrhea, oligomenorrhea
Nutritional	Low calcium intake, low vitamin D intake (equivocal evidence), energy deficit

7.8% have stress fractures.[47,48] Data are not sufficient to estimate accurately the incidence of stress fracture by type of sport; however, most data suggest highest incidence in track and field and long-distance running.[14,49,50] The cumulative annual incidence of stress fractures in track and field athletes is reported to be 8.7% to 21.1%.[14,49] In track and field athletes, stress fractures account for 6% to 20% of all injuries. Of runners seen in an orthopedic clinic, stress fractures accounted for 15.6% of all injuries. Athletes in certain sports are more at risk for specific stress fractures (**Table 2**).[1,5]

Although a significantly higher incidence of stress fractures is reported in certain groups of female athletes, overall data provide equivocal evidence to support female

Table 2
Stress fracture risk by sport

Fracture Site	Sport
Tibia	Aerobics, basketball, ballet dancing, running, soccer, swimming
Fibula	Aerobics, running, skating
Femur	Jumping activities
Calcaneus	Basketball, other jumping activities
Metatarsal	Soccer, swimming
Patella	Baseball, basketball
Pubic ramus	Fencing, jumping, running
Pars interarticularis	Gymnastics
Ribs	Baseball
Scapula	Baseball
Humerus	Baseball, cricket
Ulna	Curling, javelin, tennis
Metacarpal	Handball, tennis

gender as an independent risk factor for stress fractures.[43] Similarly, age has not been found to be an independent risk factor for stress fractures.[43] Stress fractures are most frequently reported in lower extremities; tibia being most affected followed by metatarsals and fibula.[51,52] Stress fractures of upper extremities are rare. The duration from time of diagnosis to return to play varies depending on the type, site, and grade of severity of the fracture, and ranges from 7 to 17 weeks.[44,51,52]

DIAGNOSIS

Activity-related, insidious onset of pain that is localized to the affected area is the cardinal presenting symptom of stress fracture.[1] Initially, the pain is reduced or transiently relieved with rest, allowing the athlete to continue the activity; however, progression of stress injury results in increased intensity of pain and functional deterioration or limitation of activity, which prompts the athlete to seek medical attention.[6,53–55] Pain from stress fracture is usually described as dull aching, and in the case of lower extremity injury is often aggravated by weight bearing. Onset, duration, progression, and modifying factors for the pain should be characterized. Additional history should ascertain information about other possible contributing factors for stress factors as listed in **Table 3**.[5,7,55] The affected area is usually tender to palpation. In the case of lower extremity fractures, the athlete may have a limp because of increased pain on weight bearing. If the fracture is in close proximity to a joint or involves a joint, pain is aggravated on joint movement.

Plain radiography is the initial study for confirming diagnosis of a stress fracture.[56] Plain radiographs have a high rate of false negative results because the findings suggestive of stress injury of the bone are generally not evident on plain radiographs for 2 to 4 weeks after the onset of pain.[5,56,57]

Notwithstanding the expense and accessibility, magnetic resonance imaging (MRI) has been shown to be most useful in the diagnosis of stress injury of the bone, and abnormal findings can be detected as early as within 1 to 2 days of injury.[56,58–65] MRI is useful in delineating the differential diagnosis of stress fracture that includes soft

Table 3
Main points in history

Pain	Onset, duration, quality, progression, modifying factors, radiation, location, associated symptoms such as tingling, numbness, weakness
Training regimen	Recent increase in intensity, type of activity or sport, running surface
Footwear	Type of shoes, proper fit, how old, history of use of orthotics, inserts
Medical history	Known disorders that affect bone health, osteopenia, metabolic bone disease
Medications	Use of corticosteroid or other drugs that increase risk for osteopenia, use of depomedroxy progesterone
Performance	Anabolic androgenic steroids, growth hormone, other enhancing agents
Nutrition	Caloric intake, calcium intake, vitamin D intake, weight loss
Menstrual history	Onset of menarche, amenorrhea, oligomenorrhea
Stress fractures	Details of any previous stress fractures
Systemic symptoms	Fever, rash, joint pain, undue fatigue, unintended weight loss, loss of appetite

tissue injuries affecting the same area, and more ominous conditions such as bone malignancy and osteomyelitis. Arendt and Griffiths[58] have classified stress injury of the bone into 4 grades (**Table 4**). The MRI grading system has been found to correlate with or has a prognostic significance for time to healing and return to play. Studies have shown that the average duration of recovery time for grade 1 stress injury is 3.3 weeks, whereas it is 14.3 weeks for grade 4 injury.[6,58] MRI-based grading of stress injury of the bone has also been found to be useful in guiding management of stress fractures.

The application of ultrasonography in the diagnosis of musculoskeletal disorders is increasing. Ultrasonography has been shown to be useful in the diagnosis of stress fractures of more superficial bones such as distal tibia and bones of the foot.[56] The acuity of the fracture can be assessed by power Doppler ultrasonography, which provides a semiquantitative estimate of bone turnover.[56]

Computed tomography (CT) can be used in patients in whom MRI is contraindicated. CT is sensitive in detecting stress injury of the bone and in differentiating stress fractures from other lesions of the bone such as osteoid osteoma.[56] CT scan, especially single-photon emission CT (SPECT), has been found to be sensitive in detecting pars interarticularis stress fractures (spondylolysis).

Nuclear medicine scintigraphy is highly sensitive for evaluation of bone turnover and, therefore, for detecting stress reactions 3 to 5 days after onset of pain; however, findings are nonspecific for stress fractures.[56] It also necessitates injection of a radioactive tracer with potential associated risks.

MANAGEMENT

Management of stress fractures is guided by consideration of several factors. It is important to first recognize whether the fracture is at a high-risk (**Box 1**) or low-risk site (**Table 5**).[2,3] In general, when a high-risk stress fracture is suspected or identified, orthopedic or sports medicine consultation is recommended, although this decision may be tempered by personal experience of the primary care physician and the site and severity of the fracture. While awaiting further definitive evaluation and treatment, the athlete is advised to rest from athletic activity. In case of lower extremity fractures, he or she is placed on non–weight-bearing status. Fractures at high-risk sites are at high risk for progression to compete fracture, delayed union, nonunion, and avascular necrosis.[3,6,54]

Table 4
Arendt and Griffiths grading of stress injury of bone based on MRI findings

Grade of Stress Injury	MRI Findings	Duration of Rest Needed for Healing, wk
Grade 1	Positive STIR image	3
Grade 2	Positive STIR plus positive T2-weighted images	3–6
Grade 3	Positive T1- and T2-weighted images; no definite cortical break	12–16
Grade 4	Positive T1- and T2-weighted images; fracture line visible	16

Abbreviation: STIR, Short Tau Inversion Recovery or short T1 inversion recovery.

Data from Arendt EA, Griffiths HJ. The use of MR imaging in the assessment and clinical management of stress reactions of bone in high-performance athletes. Clin Sports Med 1997;16(2):292–306, Table 2, p. 293.

Box 1
Stress fractures at high-risk sites

Femoral neck

Anterior cortex of tibia

Medial malleolus

Tarsal navicular

Base of second metatarsal

Talus

Patella

Sesmoids of great toe

Fifth metatarsal

Most athletes with fractures at low-risk sites can be managed in the primary care setting. In addition to the site of the fracture, timing of the fracture in relation to the sports season, and MRI grading when available are considered in the acute management and return to play decisions.[6,53,54] Athletes with fractures at low-risk sites toward the end of a sports season or during the off-season are recommended to rest from activity that causes pain.[6] For lower extremity fractures, some athletes may need a period of non–weight bearing.[4] The athlete is allowed alternative activities such as swimming or cycling. Athletes in the middle of a sports season may desire to continue to play and finish the season.[5,6,54] These athletes who present with pain that is not limiting their ability to function may be allowed to continue to participate in the sport within the limits of pain tolerance and acuity.[6,53–55] If the intensity of pain increases with continued activity or functional limitation occurs, sports participation is discontinued and the athlete is recommended to rest.

The time to heal and return to play for stress fractures ranges from 6 to 10 weeks depending on multiple factors including the site of injury, grade of injury severity, or other associated risk factors.[6,53–55] Evidence to support use of ultrasound, electrical and electromagnetic fields, and bisphosphonates to enhance stress fracture healing is limited and equivocal.[54,66] Some studies suggest that use of nonsteroidal anti-inflammatory drugs may delay fracture healing.[66] In the management of athletes with stress fractures, the possible risk factors that contribute to pathogenesis should be carefully reviewed and modified where possible to reduce future risk. Ensure adequate nutrition, caloric intake, and calcium and vitamin D intake. Adolescents need 1300 mg per day of calcium and 400 IU of vitamin D daily.

In addition to stress fractures, the differential diagnosis of leg pain includes exertional compartment syndrome, medial tibial stress syndrome, osteomyelitis, and

Table 5
Stress fractures at low-risk sites

Upper extremity	Clavicle, scapula, humerus, olecranon, ulna, radius, scaphoid, metacarpals
Lower extremity	Femoral shaft, tibial shaft, fibula, calcaneus, metatarsal shaft
Thorax	Ribs
Spine	Pars interarticularis, sacrum
Pelvis	Pubic rami

bone malignancy. Any adolescent with bone pain should be evaluated carefully to establish the cause of the pain. In addition to imaging, initial laboratory studies may include comprehensive metabolic panel, compete blood count, and erythrocyte sedimentation rate.

The athlete can resume unrestricted sports participation once she or he is pain free and has normal findings on examination.[6,53–55] Routine follow-up imaging studies are not indicated in most cases.

SUMMARY

Stress fractures in adolescent athletes are common injuries seen in practice. Stress fractures most frequently affect lower extremities and are most common in long-distance runners and track and field athletes. Diagnosis is based mainly on clinical evaluation. MRI is the study of choice for further delineating the stress injury of the bone. Most stress fractures that involve low-risk sites can be managed conservatively in the primary care setting and heal in 6 to 10 weeks.

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