Current Concepts in Lower Extremity Stress Fractures

Treatment is often dependent on how the fracture is classified.

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Figure 1: Fibula stress fracture-low risk

Introduction

Stress fractures are some of the most common sports injuries and can be quite debilitating. Significant morbidity is associated with this injury and can result in substantial time loss in training and competing, especially if not identified in a timely manner. A stress fracture represents an imbalance between stresses applied to the body and its ability to respond to those stresses. It will occur when stress is applied without appropriate rest. This leads to osteoclastic activity, which then outweighs osteoblastic activity, leading to failure of the bone. A proper diagnosis is therefore imperative, followed by a proper plan of care. This article presents an overview of current concepts of lower extremity stress fractures, their evaluation, classification, management, and prevention.

Physiology of the Bone

Bone tissue is one of the most metabolically active tissues in the body. It is constantly remodeling, responding to changes in mechanical loads by adapting its architecture in order to be able to sustain applied forces. There is a constant remodeling activity occurring from osteoclasts and osteoblast cells in order to achieve proper balance between forces applied to a bone and its ability to resist those forces. In the case of stress fractures, the bone becomes unable to respond in time to increased repetitive forces. This leads to weakening of the bone structure and if the applied forces continue, the bone will eventually fail, creating a stress fracture. The location of the stress fracture within the bone is also predictive of healing potential and prognosis; therefore, close attention must be paid to this. A fracture occurring on the tension side of a long bone has a much poorer prognosis, potentially resulting in a fracture gap. Conversely, a fracture occurring on the compression side has a better healing potential and will require less aggressive treatment.

Epidemiology

Stress fractures account for over 10-15% of all sports injuries seen by medical providers and are, therefore, one of the most common athletic injuries. Between 80 to 90% of stress fractures occur in the lower extremity and can affect virtually any bones, including those in the upper

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extremities. Less common locations include the pars interarticularis of the lumbar spine (seen in sports requiring repetitive upper body hyperextension such as wrestling and gymnastics), humerus (seen in throwing sports), and ribs (rowing and golfing). The incidence of stress fracture has been reported to be as high as 21% in runners. The incidence is almost twice as high in women as in men. While the tibia is the most common bone to be involved, comprising 25 to 40% of all stress fractures (some reports show up to 75%), the second metatarsal is the most common location in the foot.

Risk Factors

There are two main sources of force that bones are subjected to: 1) ground reaction forces (i.e., ground pounding of running, jumping, etc.) and 2) repetitive muscle contracture, leading to bony overload at its attachment. Proper management, therefore, requires understanding and recognizing these forces as potential causes for stress fracture. This understanding will help in identifying risk factors to which athletes are subjected. Risk factors are commonly categorized as intrinsic (the victim) or extrinsic (the cause).

• ***Intrinsic factors***

—*Biomechanical abnormality:*

> Varus/valgus malalignment of the lower extremity, at any level

> Excessive or ill-timed pronation

> Extreme foot morphology (either pes planus or cavus)

> Increased Q-angle, especially in females

> Leg length discrepancy

—*Poor physical conditioning* (body's inability to sustain stress and external forces).—*Muscle imbalances/weakness:* (An increase in muscle mass may help in shock absorption; muscle imbalances can lead to abnormal and uneven stress on the bones).

—*Prior history of stress fractures* (re-occurrence of SF reported to be as high as 50%).

—*Female gender* (hormonal imbalances seen in female athlete triad has a direct correlation with a higher incidence of stress fractures).

—*Nutrition:* Adequate Vitamin D and calcium intake is necessary in optimal bone health.

• ***Extrinsic factors***

—*Training errors:* most common cause of stress fractures (aggressive increase in training loads, leading to the body's inability to adapt).

—*Training surfaces:* currently, no studies support correlation between surface type and stress fracture, but it is speculated that a softer surface might be more resilient and offer better shock absorption.

—*Shoes:* No study proves that shoes can directly cause stress fractures, yet there can be a strong correlation between the shock absorption properties of a shoe, its ability to reduce/slow pronation and incidence of stress fractures. In other words, no shoe will cause a stress fracture by itself but it may accelerate the process of creating one.

Again, when evaluating a stress fracture, we need to understand that it is created by a failure of adaptation to stress. More than one factor can be present, and it is important to identify them in order to provide proper treatment and prevention protocol. Each athlete

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Figure 2: Surgical correction/ORIF 4th met base-high risk

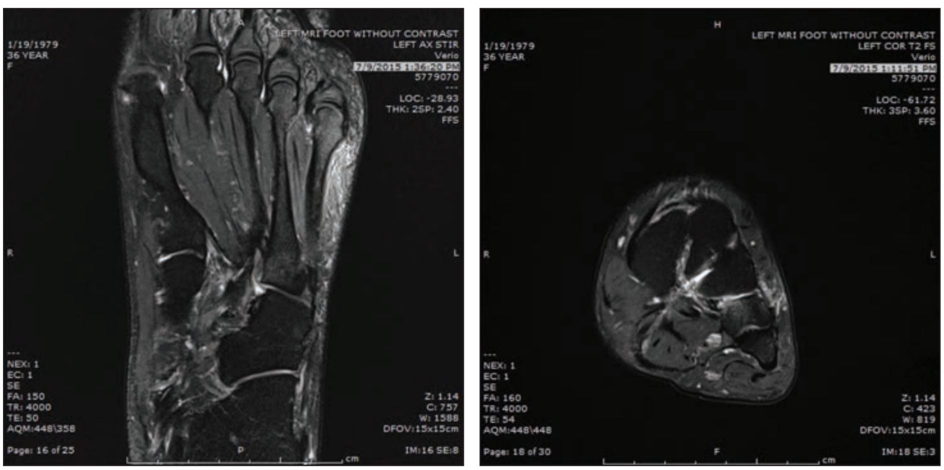

Figure 3: 4th metatarsal fracture-high risk, which went on to non-union, requiring ORIF

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should be evaluated by a specialist in accordance with a sport.

Classification

Unfortunately, there is a lack of a proper classification system used to describe stress fractures and to provide appropriate treatment recommendations and protocol. One adopted general convention is to classify a stress fracture as either high risk or low risk, which is determined by its anatomical location. This important step will lead to appropriate treatment protocol and precise prognosis.

In essence, stress fractures are identified according to their location, which in turns leads to their classification. A high risk stress fracture typically takes longer to heal, has a high failure rate with conservative treatments, oftentimes requiring surgery, and is best managed initially with a period of complete non-weight-bearing.

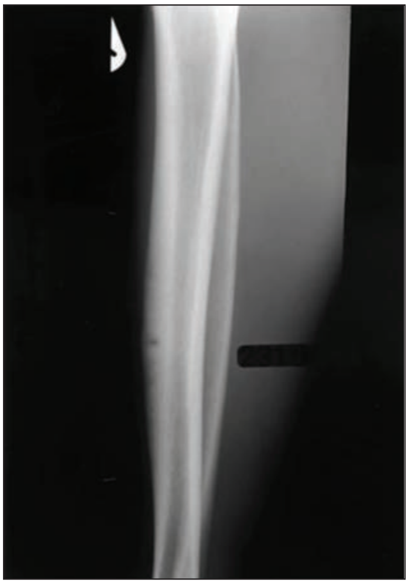

Figure 4: Anterior tibia stress fracture, high risk, required ORIF

Bone scans used to be regarded as the study of choice due to their high sensitivity, but MRI and CT scan have now become the imaging of choice.

On the other hand, a low risk stress fracture will be managed successfully with conservative measures and will necessitate no surgery, and a level of weight-bearing status is maintained throughout the recovery. It is therefore imperative, after proper diagnosis of stress fracture, to be able to classify it appropriately in order to determine the appropriate treatment course (Figures 1, 4, and 5).

Evaluation

First and foremost, a thorough history should be obtained, and information should be gathered: training regimen, prior fitness level, training conditions, shoes, nutrition, menstrual cycle, etc. Classically, the patient will present with a history of insidious onset of pain, localized to a specific bony part, occurring while exercising.

As the stress fracture progresses, the pain can be experienced even at rest. Swelling may or may not be present, depending on the bone involved. Unfortunately, studies have shown that a patient will often present after experiencing symptoms between 12 and 16 weeks on average. This can significantly delay the treatment and prolong the recovery time, especially in the case of a high risk stress fracture.

On occasion, the clinical examination can be completely unremarkable, especially if the patient presents with symptoms early on. Plain radiographs are still the first imaging study to obtain, even if they present several limitations. They are a cheap, quick, and widely available study but unfortunately are only positive in about 30%-50% of stress fractures. X-ray findings are also lagging behind and may take between two to four weeks to show bony changes associated with stress fractures, such as periosteal elevation, cortical thickening, sclerosis, and true fracture line.

Figure 5: 3rd met stress fracture-low risk

Bone scans used to be regarded as the study of choice due to their high sensitivity, but MRI and CT scan have now become the imaging of choice. They have proven to be much more specific for fractures, especially when evaluating possible stress fractures of the foot. MRI specifically has the benefit of differentiating between different bone pathology that can mimic stress fracture. Bone scans are highly sensitive but not specific, and are a poor choice to monitor recovery as they will remain positive several months to years after the fracture has healed. Yet, they might be necessary to confirm stress fractures if MRI or CT scans are negative.

High Risk vs. Low Risk

Stress fractures are generally classified as high or low risks according to their location:

- ***High Risk:***
  - *—Anterior tibial crest*
  - *—Medial malleolus*
  - *—Navicular*
  - *—4th + 5th metatarsal*
  - *—Sesamoids*

- ***Low Risk:***
  - *—Posterior tibia*
  - *—Lateral malleolus/fibula*
  - *—2nd metatarsal*
  - *—Calcaneus*
  - *—Cuboid*

General Principles of Treatment

The most crucial step in treatment is to determine the severity of

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a stress fracture as explained above, which will then assist in creating the appropriate treatment plan. Regardless of its classification, the primary goals in treating a stress fracture are 1) pain management, and 2) rest from the aggravating activity. For high risk stress fractures, patients should have a period of non-weight-bearing on the affected limb, especially if walking alone is causing pain.

For low risk stress fractures, bracing or using a protective shoe/boot is often all that is necessary. A minimum of four to six weeks will be required to heal a stress fracture, which can extend to four-plus months in the case of high risk ones. The time needed to heal is mainly dictated by symptoms, which can be frustrating for both the patient and the provider. Therefore, it is important to have an honest discussion with the patient about realistic expectations.

When bony focal tenderness has been resolved, when no edema is noted and activities of daily living are pain-free, you can progress the athlete to a safe return to sport. Be ready to individualize the treatment plan and rest time for each patient, and therefore this necessitates close follow-up visits. Since a stress fracture occurs because of mechanical forces outweighing the body's ability to adapt, a proper treatment protocol should include a thorough biomechanical evaluation to determine the potential causes of the stress fracture itself.

If abnormal alignment is identified, it can be corrected with orthotic prescription and appropriate footgear. When improper muscle balances are identified, physical therapy should be involved to provide appropriate management. Endocrinology and nutritionist referrals can be required if underlying hormonal imbalances/nutritional issues are suspected.

High Risk Fractures

In the case of high risk fracture, surgery can be the first line of treatment. Surgery will also remain the treatment of choice for displaced fractures and non-union ones, whether high risk or low risk stress fractures are involved. Surgery can consist of debridement of the non-union site with or without usage of bone graft/biologics, followed by appropriate internal fixation (Figures 2 and 3).

Adjunct Treatment Modalities

Several treatment modalities do exist which can be utilized in stress fracture treatment such as shockwave therapy, low-intensity pulsed ultrasound therapy, and hyperbaric oxygen. Unfortunately, there is no definitive treatment, and current evidence is still conflicting whether or not they provide beneficial therapeutic effects. If used safely, these modalities can provide additional support in bone healing. Additionally, there is an increasing amount of evidence to suggest that supplemental calcium and Vitamin D (1500 mg and 1000 IU daily, respectively) may help with fracture healing and should always be recommended to the patient.

A safe, alternate method of training should be offered to patients to help them maintaining their fitness.

Summary

The initial step in managing a stress fracture is to first identify/diagnose the fracture, followed by a proper classification: high vs. low risk. A high level of suspicion, appropriate imaging study, and accurate management are required. Diagnosis and treatment must be individualized, since having a stress fracture can range from simple frustration to potential lifetime disability. Evidence for any particular treatment is not strong but, in essence, should be aimed at pain control, protection of the injured limb, and should be followed by thorough biomechanical evaluation to determine the cause.

Surgery is often indicated in the treatment of high risk stress fractures or in non-union, regardless of the classification. New evidence is showing positive results with supplementation of Vitamin D and calcium to prevent and treat SF, and adjunct treatment modalities can also be beneficial. A safe, alternate method of training should be offered to patients to help them in maintaining their fitness. **PM**

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