THE TORONTO CENTRE FOR SPORTS MEDICINE & PREVENTATIVE HEALTH LTD.

Stress Fractures in the Athlete

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Special points of interest:

- Stress fractures are common in athletes especially with an insidious onset of pain early on in the season
- A high index of suspicion along with immediate investigations are necessary to make the diagnosis
- Appropriate imaging investigations are essential in making the diagnosis and planning appropriate therapy
- It is essential to immediately identify and refer high risk fractures for appropriate care
- Most low risk stress fractures respond to relative rest and progressive return to sport.
- Successful treatment must include addressing the intrinsic and extrinsic predisposing factors present in the athlete

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Overview of Stress Fractures

Stress fractures are common especially in high-level athletes but occur in all athletes and in the general population. Runners have the highest incidence of stress fractures and the tibia is the most common site of involvement.

The pathophysiology is believed to be an imbalance between bone destruction caused by physical activity and bone repair. Abnormalities of either intrinsic and/or extrinsic factors in the athlete are usually responsible for these fractures. These factors are discussed below. It is therefore necessary to identify and correct the underlying causative factors in order to have successful outcomes and prevent recurrences.

The treatment of stress fractures depends on developing a high index of suspicion and immediately instituting the appropriate investigations to prevent delays in diagnosis. It is important to pick up high risk fractures such as those of the femoral neck, anterior tibial diaphysis, navicular, talar neck and base of the fifth metatarsal as these tend to do less well with conservative management and can potentially progress to catastrophic results especially in the femoral neck. These fractures need immediate attention from a specialist.

Plain x-rays are often negative initially. Bone scans are very sensitive and helpful to confirm or reject the diagnosis. The MRI is the best technique available to investigate a suspected stress fracture as it provides both anatomical and functional information about the fracture.

Stress fractures of the upper extremities occur in the ribs and elbow, especially in throwing or swinging sports such as baseball, golf or tennis. The diagnostic procedure is similar to that in the lower extremities.

Running is the most common cause of stress fractures.

It is important to stress the need to be aggressive with respect to obtaining diagnostic tests in assessing stress fractures, especially if involving areas which are at high risk of complications. High risk fractures need immediate referral to an orthopaedic surgeon. Most other fractures respond well to a program of relative rest and graduated activities.

Epidemiology

It is felt that the incidence of stress fractures is increasing due to the ever-increasing participation of children in sports and the degree of intensity which is demanded of them.

The lower extremity and the tibia in particular are the most common sites of stress fracture in all sport and physical activities. There is an increasing incidence of upper extremity fractures related to an increasing participation in throwing sports at high levels of participation.

The participation of younger and younger children who have decreased bone mass as well as females in sports which encourage low body mass has also provided an increased at risk population for stress fractures.

Now more than ever physicians have to be on the look out for the potential of a stress fracture with the insidious onset of pain in any athlete especially at the beginning of the season or where there has been a history of a sudden increase in activity or in high risk populations.

Predisposing intrinsic and extrinsic factors must be addressed in treatment and prevention of stress fractures. Be on the lookout for the female athlete triad.

Pathophysiology

Bone is constantly remodeling due to the activity of osteoclasts and osteoblasts. Stress injury to bone occurs on a continuum from normal bone remodeling and repair to an actual fracture. The steps involved in the initiation of a stress fracture are thought to be the accumulation of micro trauma from repetitive loading of bone to fatigue failure. The next step is that the fatigue failure persists leading to crack initiation. If the crack is not repaired adequately it leads to crack propagation and fracture.

Intrinsic factors include abnormal diet, hormonal imbalances including the female athlete triad (amenorrhea, disordered eating and osteoporosis), and biomechanical factors. Hormonal imbalances are more prevalent in females and in sports which put a premium on a lean body mass. Poor dietary habits mainly involve low intake of Calcium and vitamin D. These should be looked for in any athlete presenting with a stress fracture and adequately addressed.

There is evidence that an biomechanical abnormalities such as increased external rotation of the hip, leg length discrepancies, decreased cross sectional area of the tibial shaft, significant tibia varus, significant pes cavus or pes planus predisposes one to stress fractures.

Extrinsic factors involve training regimen, technique, terrain and shoe wear. These are usually the most easily manipulated variables in the treatment of stress fractures.

Clinical Evaluation

Plain x-rays are often negative initially. A bone scan or MRI are often needed to rule out a stress fracture.

Symptoms may consist only of a vague insidious onset of pain. Initially the pain may be present only during activities. If untreated it may progress to pain persisting after activities and at rest.

The physical examination may reveal a specific site of tenderness and associated swelling in bones which are close to the body surface such as the metatarsals or tibia. An older stress fracture may have developed a palpable callus. One must be on the lookout for the "high risk" stress fractures as they are more likely to lead to delayed or non unions or complete fractures with their inherent complications. All high risk fractures should be referred for immediate attention by an orthopaedic surgeon.

The differential diagnosis of stress fractures is extensive and may include muscle strain, medial tibial stress syndrome or shin splints and stress reaction of bone as well as infection, osteoid osteoma, neoplasm, exertional compartment syndrome or nerve entrapment.

Imaging is necessary to confirm or exclude the diagnosis. A good history along with imaging studies should help eliminate many of these diagnostic possibilities.

Negative x-ray in an athlete with a second metatarsal stress fracture. A bone scan can quickly rule out a stress fracture in such a case.

Imaging

It is suggested that high resolution radiographs be obtained in initially even though the findings lag behind the clinical presentation and may be negative for weeks.

Bone scans can be positive before symptoms develop and are very sensitive in picking up stress fractures but not very specific. Tumours and infections may present in similar ways however the history is helpful in these cases. If the bone scan is negative the patient does not have a stress fracture.

CT scans have been used to obtain clearer anatomic information especially in high risk fractures. In these cases the decision to operate or not often depends on the location and extent of the fracture line.

The MRI has the benefit of providing both anatomic information and functional information about the healing activity in the surrounding bone and has become the investigation of choice. One can see marrow edema on the MRI indicative of bone remodeling on a fat suppressed sequence (see image page 3). This however may be positive for up to 6 months after the injury. In runners bone marrow edema may show up in various sites most likely indicating activity induced stress on the bones from running. The clinical significance of these findings in asymptomatic athletes is uncertain.

Treatment Principles

This is dependent on whether a fracture is low or high risk. Low risk fractures respond well to period of relative rest for two to six weeks with progressive return to activities. The activity level in low risk fractures is usually guided by the athlete's symptoms. It is important to remember that not all low risk fractures respond favorably to rest. Pneumatic leg braces have been shown to allow athletes with tibial fractures to return to activities pain free faster. Use of a bone stimulator has not been shown conclusively to decrease healing time. Pulsed ultrasound has also shown conflicting results.

Identifying and correcting any intrinsic and extrinsic factors which can adversely affect bone repair should be part of any treatment. This would include treatment of hormonal imbalances, eating disorders, leg length discrepancies, significant pes cavus or pes planus deformities, training errors and shoe wear.

High risk fractures must be recognized immediately. When suspicious of a high risk stress fracture, referral on an urgent basis to an orthopaedic surgeon is indicated while keeping the athlete non weight bearing status. The treatment of a high risk stress fracture and whether to operate depends on the fracture site and its characteristics, the athlete's goals and activity level and any predisposing intrinsic factors which may delay healing through conservative means.

Relative rest from causative stresses is usually sufficient treatment in most non high risk stress fractures.

Tibial Stress Fractures

These represent 20 to 75% of all stress fractures. The most prominent type is the low risk posteromedial cortex fracture. This low risk fracture is treated by relative rest. Findings are usually limited to tenderness over the shin. Radiographs are often negative and a bone scan or MRI would be needed to make the diagnosis.

Treatment with a pneumatic leg brace has been shown to be effective in decreasing the return to play time. Relative rest for 3-6 weeks with a progressive return to activities is common and is dependent on decreasing pain and localized tenderness.

Decreased cross-sectional area of the tibial diaphysis as well as increased external rotation of the hips have been shown to increase the risk of tibial stress fractures in military recruits. It is also thought that a significant pes cavus or pes planus may increase the risk of stress fractures in the tibia. Despite adequate rest some low risk fractures may fail to heal.

The "dreaded black line" (along the anterior tibial cortex) represents a high risk tibial fracture. In these cases rest, pneumatic leg bracing, ultrasound or electrical stimulation may be attempted to heal the fracture. Failure of conservative treatment (4-6 months) may require intramedullary nailing of the tibia. With surgical intervention one can see radiographic evidence of union after three months. Return to sport may be accomplished by four months in many cases.

Femoral neck and other high risk stress fractures must be identified and ruled out immediately if suspected.

Femoral Stress Fractures

Stress fractures can occur anywhere along the length of the femur. Most of these can be treated with relative rest and progressive activity as tolerated. Femoral neck stress fractures are considered high-risk and are usually classified as superior neck/tension type or inferior neck/compression type fractures. The superior fractures seem to be more prone to progression of the fracture and non-union. Femoral neck fractures should be referred for immediate care by an orthopaedic surgeon. Clinically there may be pain at the extremes of passive range of motion of the hip. Athletes may ambulate with an antalgic gait. Active straight leg raise and logrolling of the femur may exacerbate the pain. The hop and fulcrum tests are used exacerbate the pain and localize the site of femoral shaft stress fractures.

Most femoral stress fractures are treated non-operatively with excellent results. A period of relative rest including weight-bearing with crutches may be necessary. A gradual return to activity would be indicated as the pain subsides.

Operative intervention is reserved for any failed conservative treatment and any displaced femoral fracture or femoral neck stress fractures. Return to play is based on pain-free full weight-bearing with no palpable tenderness and follow-up imaging studies with signs of a healed fracture.

MRI of a stress fracture of the inferior femoral neck (fat suppressed sequence).

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Stress Fractures of the Metatarsals

Metatarsal fractures are involved in 9-19% of the stress fractures in athletes with the second and third metatarsal shaft accounting for 80% of the fractures. Any metatarsal can be involved with the 5th metatarsal representing one of the high risk fractures.

It is important to get weight bearing radiographs to assess for any angulation or displacement which would require surgical consultation. An isolated low risk fracture with minimal or no displacement is generally treated with a hard sole postoperative shoe or a walker boot with progressive weight-bearing to a well-padded shoe at three to four weeks.

Proximal fifth metatarsal fractures are high risk fractures occurring at the proximal diaphysis of the 5th metatarsal (location of a Jones fracture). There are other fractures of the fifth MT base (more proximal) which are not high risk. It is therefore important to distinguish between the types of fractures as the treatment can very greatly from weight-bearing in a walking boot to nonweightbearing in a short leg cast for 6-8 weeks. Failure to heal would require surgical screw fixation of the fracture.

In high level athletes surgical intervention may be the primary intervention in a 5th MT fracture. This course of action may be chosen due to the fracture's nature to be prone to complications or as a choice to help speed up the healing and decrease the down time in an athlete's season.

Be suspicious of insidious onset of foot pain in running or track athletes. Lateral foot pain may represent 5th MT fracture and mid foot pain may represent a navicular fracture. Both are high risk.

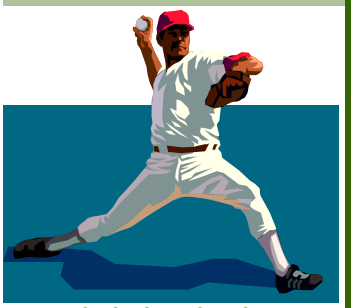
Navicular Stress Fractures

These high risk fractures are often missed initially. Time to diagnosis can be delayed for up to 7-28 weeks. Suspect one in any weight bearing athlete who develops insidious onset of mid-foot pain and tenderness. This condition is more common in running and track and field athletes and in those with a recent history of increased activities.

This fracture can be ruled out by a bone scan. CT or MRI are necessary to characterize the fracture. Classification of navicular fractures into three types has been proposed. Type 1 is a break in the dorsal cortex, type 2 extends into the body of the navicular and type 3 extends into a second cortex.

These are high risk fractures and aggressive nonoperative or operative treatment is necessary. Non-operative treatment includes nonweightbearing cast for 6 weeks until the fracture is healed thereupon gradual weight bearing can resume if tenderness has resolved. If the pain persists despite fracture healing the patient can be allowed to bear weight in a boot until the pain resolves. This fracture may require up to eight months for full return to activity.

Operative treatment consists of percutaneous screw fixation. Type 3 fractures are usually initially treated surgically. Return to activity ranges from 3 months for a type 1 to 7 months or longer for type 3.



Be on the lookout for olecranon fractures in throwing athletes.

The Ribs and Upper Extremities

Rib fractures occur in rowing, rugby, golf, weightlifting, volleyball, gymnastics, judo, tennis, table tennis, basketball and many other sports. Muscular forces are predominantly responsible. The fracture may occur in any portion of the rib. The first rib is a very common area for rib fractures to occur in athletes involved in overhead positioning of the arm such as baseball pitching, basketball, lacrosse etc.. Treatment includes relative rest from throwing. The middle ribs are usually fractured by throwing and swinging sports. The posterolateral aspects of the fourth through sixth ribs on the leading arm side are most commonly involved in golfers.

Overall rib fractures heal uneventfully.

Stress fractures of the olecranon are most common in the throwing athlete such as in baseball pitchers. Management involves rest. If a fracture line has developed operative intervention may be indicated. Diagnosis is made with plain radiographs bone scan and MRI.

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