Operative Techniques in
Sports Medicine

Femoral Neck Stress Fractures

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Stress fractures are common overuse injuries in the lower extremities that occur with either abnormal stress on normal bone (fatigue fracture) or normal stress on abnormal bone (insufficiency fracture). Location of a stress fracture and associated potential for delayed union, nonunion, and refracture facilitate designation of a fracture as either "high risk" or "low risk." Femoral neck stress fractures account for less than 5% of all stress fractures. Based on the biomechanics of the proximal femur, these fractures may be on the inferomedial compression side or the superolateral tension side. Tension-side fractures are of "high risk" and compression-side fractures are of "low risk." Once a diagnosis of stress fracture is made, a thorough evaluation for modifiable endocrinologic and nutritional risk factors is undertaken and a treatment and prevention program commenced. Nonsurgical treatment with crutch-assisted non−weight bearing ambulation is indicated for incomplete compression-side fractures. Surgical treatment is indicated for (1) complete fracture with or without displacement, (2) tension-sided incomplete fractures, and (3) compression-sided incomplete fractures that have failed nonsurgical treatment for a minimum of 6 weeks. Percutaneous screw fixation with 6.5- or 7.3-mm screws is the standard of care for surgical treatment. Stress fracture displacement requires urgent anatomical reduction. Thus, if a closed reduction is unable to be achieved under anesthesia, then an anterior Smith-Petersen approach is necessary to anatomically reduce and fix the fracture. Postoperatively, following percutaneous screw fixation of a nondisplaced stress fracture, patients may begin weight bearing as tolerated. Complications include displacement, nonunion, delayed union, varus malunion, and avascular necrosis.
Oper Tech Sports Med 23:241-247

KEYWORDS stress fracture, hip, femoral neck, overuse injury

Introduction

Stress fractures are common overuse injuries in the lower extremities. Repetitive episodes of high-intensity or extended-duration axial load to the leg places the bone at risk of stress-related injury. The femoral neck is an uncommon location for stress fracture (less than 5% of all stress fractures). Stress fracture evaluation and management begins with a thorough history, physical examination, and radiographic examination. Fracture location, type, and grade permits generic dichotomized classification of "low-risk" and "high-risk" fractures. Tension-side femoral neck stress fractures are considered "high-risk" because of their potential for displacement, nonunion, and avascular necrosis if displaced. Thus, surgical treatment is the standard of care for tension-sided injuries. Compression-side femoral neck stress fractures are considered to be of "low risk" owing to the biomechanics of the medial femoral neck and their higher likelihood for healing with nonsurgical treatment with non−weight bearing crutch-assisted gait. In the initial and all follow-up evaluations, risk factors for femoral neck stress fracture (Table 1) must be identified, treated, and prevented.

Stress Fracture Pathophysiology

Stress fractures are common overuse injuries in the lower extremities. Generally speaking, stress fractures occur with abnormal stress on normal bone (fatigue fracture) or with normal stress on abnormal bone (insufficiency fracture). Repeated bouts of high-intensity or extended-duration load to the bone may place individuals at risk for stress fracture.[1]

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http://dx.doi.org/10.1053/j.otsm.2015.07.001
1060-1872//

Table 1 Risk Factors For Femoral Neck Stress Fracture

Prior stress fracture
Rapid increase in training intensity (speed)
Rapid increase in training volume (distance)
Female athlete triad (or tetrad)
Coxa vara
Leg-length discrepancy
Training errors
Hard running surfaces
Insufficiency fracture risks
Metabolic bone disease
Chronic renal disease
Endocrinopathy
Smoking
Infection
Bone tumor at femoral neck
Postradiation therapy

In these situations, the reparative capacity of the bone cannot overcome the destructive loads placed on it. Stress fractures are most commonly observed in the tibia (24%), tarsal navicular (18%), metatarsal (16%), fibula (16%), and femoral neck (5%).[2,3] Endurance athletes may be particularly at risk, especially females, military recruits, runners, and triathletes.[4,5]

Microtrauma to bone occurs with physical activity that induces strain.[6] In normal bone, the microdamage is repaired and osseous homeostasis maintained. An increase in the number or size of the microcracks may lead to eventual fatigue failure of the bone—stress fracture. This pathology represents a spectrum of injury from stress response to incomplete fracture to complete nondisplaced fracture line to displaced fracture.[6] Fracture healing is multifactorial. However, the location may be the most important predictor of delayed union, nonunion, and refracture. Fractures in locations prone to these 3 outcomes are categorized as "high risk."[7] These include anterior tibial cortex, medial malleolus, talar neck, dorsal tarsal navicular, proximal fifth metatarsal metaphysis, tension side patella, and tension side of the femoral neck. The risk of avascular necrosis following treatment of displaced femoral neck fractures in adults may be as high as 45%.[8,9]

Proximal Femoral Anatomy

The hip is a synovial ball-and-socket joint, comprising the spherical femoral head and acetabulum. Recent appreciation of differing degrees of severity of nonarthritic hip pathology related to femoroacetabular impingement and dysplasia has significantly improved the understanding of "normal hip anatomy." The femoral neck is composed of both compact cortical and cancellous trabecular bone. The proximal femur can be radiographically analyzed using the appearance of the trabecular group (compressive, tensile, and greater trochanteric) and type (primary and secondary) (Fig. 1A).[10] During upright gait, there exists a coronal plane rotatory equilibrium between vectors of body weight and abductor tension to maintain a level pelvis (Fig. 1B). The resultant moment is responsible for designation of "compressive" and "tensile" sides of the femoral neck.

Deviation away from normal femoral neck anatomy may place excessive stress on both the hip joint and the femoral neck. The normal neck-shaft angle (angle of inclination and caput-collum-diaphyseal) angle is approximately 125°.[11] In patients with coxa vara (decreased neck-shaft angle), the tip of the greater trochanter is above the center of the femoral head, the abductor muscle length is shortened, and there is an increase in abductor lever arm. Thus, the latter requires less abductor muscle force to maintain a level pelvis, beneficial for those with abductor weakness. However, the increased abductor lever arm also increases the bending moment across the tension side of the femoral neck, placing it at risk of femoral neck fracture. In patients with coxa valga (increased neck-shaft angle), the tip of the greater trochanter is below the center of the femoral head, the abductor muscle length is increased, and there is a decrease in abductor lever arm. Thus, the latter requires greater abductor muscle force to maintain a level pelvis. The decrease in abductor lever arm decreases the bending moment across the femoral neck.

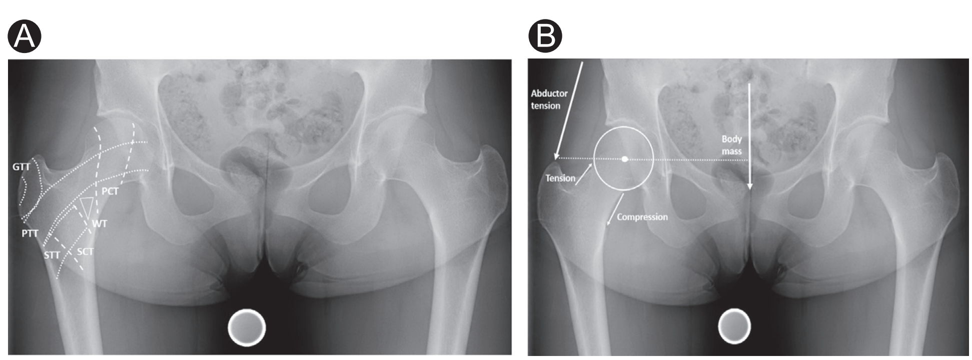

Figure 1 (A) Anteroposterior (AP) radiograph of an 18-year-old woman with outlined illustration of trabeculae of proximal femur. GTT, greater trochanteric trabeculae; PCT, primary compressive trabeculae; PTT, primary tensile trabeculae; SCT, secondary compressive trabeculae; STT, secondary tensile trabeculae; WT, Ward's triangle. (B) Anteroposterior (AP) radiograph of an 18-year-old woman with hip center of rotation marked. The product of the force of body weight and its associated moment arm equals the product of the abductor muscle force and its associated moment arm. According to Newton's third law of motion, for every action (abductor muscle tension and body weight), there is an equal and opposite reaction (joint reaction force).