Stress Fractures of the Lower Extremity

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Objectives

• Understand the risk factors of lower extremity stress fractures
• Understand the pertinent history of stress fractures
• Understand the role of imaging in detecting stress fractures
• Know the common stress fractures of the lower extremity
• Know the treatment options for the fractures

Stress Fractures

• Overuse injury
• Abnormal balance between osteoblast and osteoclast activity
• Occur most often in the lower extremity

Disclosures

• I have none

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Stress Fractures

- Femur
- Tibia
- Fibula
- Calcaneus
- Navicular
- Metatarsals
- Sesamoids

Risk Factors

- Cavus foot
- Long second metatarsal
- Metatarsus adductus
- Amenorrhea
- Hyperthyroidism
- Malnutrition
- Training errors
- Poor footwear

History

- Pain with exertion
  - May progress to pain with daily activities
- Relief with rest
- Training errors
  - Rapid increase in intensity, duration, or frequency
  - No rest day
- Ask about normal menstruation in females
- Ask about vitamin deficiencies (vitamin D) or disordered eating

Exam

- Look for abnormal alignment
- Swelling
- Warmth
- Tenderness
- Pain with percussion
- Pain with 3-point stress
- Pain with single leg hop

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Imaging
- Standard x-rays
- Bone Scan
- CT
- MR

X-ray
- 320 stress fractures in athletes
  - Pain to onset x-ray changes
    - Weeks to months
    - Average 10 to 21 days
    - Changes in 30-70% of cases

X-ray
- **Diaphyseal**
  - Cortical
  - Transverse
  - Fracture line followed by callus
  - Example: 5th MT diaphysis

X-ray
- **Metaphyseal**
  - Cancellous
  - Perpendicular to stress
  - Sclerosis
  - Example: Calcaneus

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Bone Scan

- Focal increased activity
- Increased bone turnover
- Sensitive

CT

- Fracture line
- Callus
- Specific
- Radiation

MR

- Increased marrow edema
- Linear decreased signal
- Associated soft tissue swelling or joint effusion
- Sensitive and specific
- No radiation

Treatment

- Confirm diagnosis
  - Differentiate between tension side and compression side in the femoral neck and tibia
  - Clearance prior to important event
- Patient education
- Rest
- Avoid NSAIDs
  - Some evidence that NSAIDs interfere with fracture healing
- Vitamin D replacement if indicated

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Treatment
• Immobilization
• Bone stimulation
• Open reduction internal fixation
• Cross-training/rehabilitation
• Gradual return to sport

Femur
• Superior lateral
  – Tension
• Inferior medial
  – Compression

Femur
• Superior lateral
  – Common in runners
  – Insidious onset of anterior thigh or groin pain
  – Physical exam is typically benign
  – Initial x-rays may be negative
  – Non-weightbearing and obtain an MRI to confirm the diagnosis

Femur
• Superior lateral
  – Treatment
    • ORIF with percutaneous screw fixation

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Femur

• Inferior medial
  – Common in runners
  – Insidious onset of anterior thigh or groin pain
  – Physical exam is typically benign
  – Initial x-rays may be negative
  – Non-weightbearing and obtain an MRI to confirm the diagnosis

• Inferior medial
  – Treatment
  • Non-weightbearing on crutches and gradual return to activities for fracture lines less than 50% of the width of the femoral neck
  • ORIF with percutaneous screw fixation for fracture lines greater than 50%
Medial Tibial Stress Syndrome

• “Shin splints”
• Pain at the posteromedial border of the tibia
• 15% of all running injuries
• Thought to be a traction periostitis of the posteromedial tibia (attachment of the posterior tibialis, flexor digitorum longus, or soleus muscles)

Medial Tibial Stress Syndrome

• Usually a history of poor conditioning, training errors, or sloped/banked surfaces (excessive foot pronation)
• Exam demonstrates longitudinal tenderness along the posteromedial tibia, also look for valgus hindfoot/pes planus
• X-rays may show cortex irregularity along the posterior tibialis origin
• MRI will show marrow edema in a longitudinal pattern without fracture line

Medial Tibial Stress Syndrome

• Treatment
  • Relative rest (25-75% reduction in training)
  • Stretching
  • Medial posted shoes or orthotics if needed
  • Gradual return to full training
  • Correct training errors

Posterior-medial Tibia Stress Fracture

• Same predisposing factors as MTSS

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Posterior-medial Tibia

- History of pain with exertion that is relieved with rest
  - May progress to pain with normal walking
- Exam shows focal tenderness
  - May also see swelling or limp
- X-rays may show periosteal reaction, sclerosis, or fracture line
- MRI will show marrow edema and may show fracture line

Posterior-medial Tibia

- Treatment consists of rest
  - May require non-weightbearing or immobilization initially
  - No impact activities for 6 weeks
  - May cross train during this time
    - Swimming, stationary bike, elliptical
  - Gradual return to training

Anterior Tibia Stress Fracture

- Less common
- “Dreaded black line”
- Increased risk of non-union
- Focal anterior tenderness on exam
- MRI if needed to confirm

Anterior Tibia

- Treatment
  - Non-weightbearing/Immobilization
    - Up to 4-6 months
  - Possible IM fixation
  - Bone stimulator
  - Cross training
  - Rehabilitation
  - Gradual return to play
<table>
<thead>
<tr>
<th>Fibula</th>
<th>Navicular</th>
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</thead>
<tbody>
<tr>
<td>• Valgus heel/Pronation</td>
<td>• Central hypovascular zone</td>
</tr>
<tr>
<td>• Treatment</td>
<td>• Risk of AVN or non-union</td>
</tr>
<tr>
<td>– Rest</td>
<td>• Pain with WB</td>
</tr>
<tr>
<td>– Cast boot</td>
<td>• Tenderness over the navicular</td>
</tr>
<tr>
<td>– Functional brace</td>
<td></td>
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<tr>
<td>– Medial posted shoe or insert</td>
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</table>

<table>
<thead>
<tr>
<th>Navicular</th>
<th>Calcaneus</th>
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</thead>
<tbody>
<tr>
<td>• Treatment</td>
<td>• Tender tuberosity</td>
</tr>
<tr>
<td>– Non-displaced</td>
<td>• Painful squeeze test</td>
</tr>
<tr>
<td>• Non-weight bearing</td>
<td>• Non-weight bearing</td>
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<tr>
<td>– 6-8 weeks</td>
<td>• Cast-boot</td>
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<tr>
<td>• Cast-boot</td>
<td>• Cushioned heel</td>
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<tr>
<td>• Motion control insert</td>
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<tr>
<td>• Bone stimulator</td>
<td></td>
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<tr>
<td>– Displaced, recalcitrant,</td>
<td></td>
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<tr>
<td>sclerotic</td>
<td></td>
</tr>
<tr>
<td>• ORIF</td>
<td></td>
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<tr>
<td>• Autologous bone graft</td>
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</table>
Metatarsals 1-4

- 2nd most common
- Risk factors
  - Varus foot
  - Cavus foot
  - Adducted foot
  - Anterior ankle impingement
- Treatment – cast boot and protected weight-bearing

Metatarsals 1-4

- Tenderness to the metatarsal
- X-rays may be negative initially
- Treatment
  - Cast boot and protected weightbearing
  - Crosstraining
  - Gradual return to training after 6 weeks

5th Metatarsal

- Metaphyseal-diaphyseal junction
- Risk factors
  - Varus heel
  - Cavus foot
  - Adducted foot

Metaphyseal-Diaphyseal Classification

- Acute (aka Jones fracture)
- Acute-on-chronic
- Chronic (stress fracture)
Imaging - Proximal metaphyseal-diaphyseal junction fractures

- Transverse
- Corresponds to the articulation between the fourth and fifth metatarsal base
- Acute
  - Clean, narrow, and distinct fracture line

Imaging - Proximal metaphyseal-diaphyseal junction fractures

- Acute-on-chronic fracture
  - acute fracture line over thickened and sclerotic bone

Imaging - Proximal metaphyseal-diaphyseal junction fractures

- Chronic
  - Sclerosis
  - Cortical thickening
  - Obliteration of the medullary canal

Imaging

- MR
  - Occult fractures
  - Early stress fractures
    - Intramedullary edema
    - Low signal line confirms a fracture

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Treatment - Proximal Metaphyseal-Diaphyseal Fracture

- Potential vascular watershed
- Non-weight bearing
- Short leg cast
- Up to 12 weeks

Complications - Proximal Metaphyseal-Diaphyseal Fractures

- Non-surgical treatment
  - Delayed union
  - Nonunion
  - Malunion
  - Re-fracture

Treatment - Proximal Metaphyseal-Diaphyseal Fracture

- Surgical treatment
  - Treatment failures
  - Healthy, athletic patients
- ORIF
- Percutaneous intramedullary fixation
- Bone graft

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Complications - Proximal Metaphyseal-Diaphyseal Fractures

- Surgical treatment
  - Prominent, failed, incarcerated, or painful hardware
  - Sural neuroma

Treatment - Proximal Metaphyseal-Diaphyseal Fracture

- Hindfoot varus
  - Motion control shoe
  - Lateral posted shoe
  - Lateral posted insert
  - Concomitant calcaneal osteotomy

Sesamoid injury

- Sesamoiditis
- Sesamoid stress fracture
- Tibial sesamoid most commonly affected
- Seen in dancers, runners, basketball, tennis, and cleat sports
- Tenderness at the affected sesamoid, pain with dorsiflexion of the great toe, pain with resisted flexion of the great toe
**Sesamoid injury**

- X-rays may be negative
- MRI can show edema or fracture line

**Treatment**
- Rest
- Reduced weight bearing
- Cast
- Surgical resection for failed conservative treatment
  - 3+ months
  - Complications: chronic pain, cock up deformity, hallux valgus (tibial) or varus (fibular)

**Vitamin D and Stress Fractures**

- Several military studies associate stress fracture risk with lower vitamin D levels
- One study showed that a levels of 6.5-26.9 ng/ml (20 ng/ml) had double the risk of those in the 40.2-112.5 (50 ng/ml) range
- Another study supplementing 2000 mg calcium and 800 IU vitamin D showed a 20% reduction in the incidence of stress fractures

**Who is at risk?**

- Limited solar exposure
  - Northern latitudes, indoor athletes, increased clothing and sunscreen use
- Low dietary intake of vitamin D
  - Oily fish
  - Fortified foods such as milk
  - Mushrooms
- History of stress fracture

**Vitamin D Supplements and Dosing**

- Recommended daily intake of D3
  - 600-800 IU
  - Some experts believe this should be increased to 1000-2000 IU
  - Maximum tolerable dose is 4000 IU
- Recommended daily intake of calcium
  - 1200 mg
Vitamin D Replacement

- Current recommended level is 40 ng/ml
- D2 50,000 IU weekly for 8 weeks  
  – <30ng/ml will require a second round
- D3 1,000 IU daily for every 10ng/ml short for 6 weeks
- Repeat level after course

Thank you!

- Levy J: Stress fractures of the first metatarsal.  
- Mosekilde, L.  *Vitamin D and the Elderly.*  

Thank you!

- Baxter DE, Zingas C: *J Am Acad Orthop Surg*  
  3(3):136-145, 1995
  Scintigraphic uptake of 99mTc at non-painful sites in athletes with stress fractures.  

Thank you!

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