Stress Fractures of the Lower Extremities

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Relevant Disclosures or Conflicts of Interest

Dr. Mark Foreman has no relevant financial relationships with commercial interests to disclose.

What is a stress fracture?

• A partial or complete fracture of bone that results from repeated application of a stress lower than that required to fracture the bone in a single loading situation

• Incidence has not been quantified, but children clearly have fewer fractures than adolescents, who have fewer than adults
**Pathophysiology - Mechanical**

- Wolf’s Law – Bone remodels with stress
  - This mechanical stress is a function of the magnitude, direction, and frequency of the loading cycle, as well as its rate and duration
- Constant remodeling with bone formation and resorption
- Stress fractures occur with abnormal forces on bone where repetitive musculoskeletal demands are made without adequate time between training cycles to allow resolution of subclinical bone stress injury
- Fracture due imbalance in osteoclastic vs. osteoblastic activity
  - There is a greater initial osteoclastic than osteoblastic response to increased bone stress which occurs during the first 2 to 3 weeks of training
  - This results in a transient period of diminished bone mass before enhanced bone formation in response to training.
- This vulnerable time at 3 weeks is when occurrence of a stress fracture is most common

**Pathophysiology - Hormonal**

Hormonal Factors:

- Female athletes are especially prone to calcium balance disorders due to dietary factors/eating disorders as well as exercise-induced menstrual irregularities, including secondary amenorrhea leading to osteoporosis, the so called “female triad”
- Males can develop lower testosterone levels with increased endurance training

**Stress fractures of the Lower Extremities**

- Muscle forces leading to stress fracture
  - Change of remodeling rate
  - Bone formation lags behind bone resorption
  - Focal microfractures
  - Periosteal/cortical/endosteal response (stress reaction)
    - Linear stress fracture
    - Displaced fracture
Diagnosis

History
- Insidious onset of vague, aching pain without specific traumatic event
- Menstrual irregularities in female athletes common
- Recent overuse or change in training regimen/activity

Diagnosis

Physical exam
- Discrete, point tenderness over fracture site associated with occasional swelling
- Erythema and warmth may be present but are much less likely
- May present with limp but rarely with muscular atrophy
- Joint ROM is usually not affected
- Percussion and vibratory stimuli have been reported to aid in diagnosis but are usually unnecessary

Diagnosis

- Imaging Studies:
  - Plain X-rays
  - Bone Scan
  - MRI
Imaging Studies

Plain X-rays:
- Are sufficient in approximately 2/3 of cases but can be misleading. Bone response can be periosteal, endosteal, or intra-cortical
- If very early in the process, may be negative initially but will usually show up radiographically within 2 to 3 weeks after initial visit

Proximal tibial stress fracture with periosteal and endosteal responses in a 13 year old cross-country runner

Middle aged female with 2nd metatarsal stress fracture
Imaging Studies
Bone Scintigraphy (Bone Scan)

- Helpful in the early detection especially if x-rays are negative and the diagnosis is in question. Can be positive as early as 24 to 48 hours after injury
- Very sensitive but not specific
- Not valuable in monitoring healing

Imaging Studies
MRI
- Very sensitive and much more specific than bone scan. Will see periosteal as well as bone marrow edema.
- Characteristically low signal T1 initially, high on T2. Once out of acute phase T1 and STIR best
- Better accuracy in diagnosis than bone scan in terms of definition of anatomy of the fracture site
- Much more expensive modality
- Results if any imaging modality must be clinically correlated before treatment is begun
Stress fractures of the Lower Extremities

- Differential diagnosis
  - Tibial Shaft – Medial-Tibial Stress Syndrome (Shin Splints)
  - Exertional Compartment syndrome
  - Tibial Tubercle Apophysitis “Osgood Schlatter’s Disease”
  - Calcaneus – Apophysitis “Sever’s Disease”
  - Femur – periosteal reaction confused with osteosarcoma

Stress fracture vs. “Shin splints”
Distal femoral stress fracture in a 14 year old soccer player. The lesion was originally diagnosed as an osteosarcoma.

Treatment – “Low Risk Fractures”

- R/O underlying metabolic or endocrine causes
- Modify exercise routine
- Six to 12 weeks of rest with gradual resumption of activities
- Occasional bracing or casting if “potentially unstable” or at “higher risk”
- Correct any mal-alignment or training issues

**TABLE 30F-1**

<table>
<thead>
<tr>
<th>Bone</th>
<th>Location</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hallucal sesamoids</td>
<td>Medial &gt; lateral</td>
<td>Running, football, golf, gymnastics</td>
</tr>
<tr>
<td>Metatarsal shaft/neck</td>
<td>2, 3, 4</td>
<td>Military recruits, running</td>
</tr>
<tr>
<td>Metatarsal base</td>
<td>2nd</td>
<td>Ballet dancers</td>
</tr>
<tr>
<td>Metatarsal shaft-base</td>
<td>5th</td>
<td>Basketball, football</td>
</tr>
<tr>
<td>(“Jones fracture”)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navicular</td>
<td>Dorsal, mid</td>
<td>Track and field, basketball, football, soccer</td>
</tr>
<tr>
<td>Medial malleolus</td>
<td></td>
<td>Running, jumping, basketball</td>
</tr>
<tr>
<td>Tibia</td>
<td>Shaft or distal metaphysis</td>
<td>Distance runners</td>
</tr>
</tbody>
</table>
Calcaneal tuberosity stress fracture in a 29 y/o female runner

Middle aged female with 2nd metatarsal stress fracture

Treatment – “High Risk Fractures”
- High risk stress fractures are in the minority and are those that have a propensity for difficult healing, persistent nonunion, and risk for fracture displacement
- Surgery may be required for these and follow the same basic indications as for other fractures: nonunion, malunion, or at risk for displacement that would lead to either of the two or significant morbidity
- Examples include the patella, medial malleolus, talus, tarsal navicular, and fifth metatarsal base.
- These also include “tension sided” fractures such as the anterior tibial diaphysis and superior femoral neck
Femoral neck stress fracture

Femoral neck tension sided stress fracture

Tibial stress fracture in an 18 y/o basketball player (high risk anterior tibial cortex)
Tibial stress fracture

Navicular Stress Fracture

- Seen in active athletes involved in sprinting and jumping sports
- Nondescript medial arch pain worse with activity
- Occurs in the central 1/3 of the bone (vascular zone)
- CT scan study of choice
- If diagnosed early, high union rate with NWB cast immobilization for 6-8 weeks. High rate of nonunion with weight-bearing
- Displaced fractures, nonunion, delayed union: ORIF
- Semirigid molded arch support for rehab and after return to athletic activities
Tarsal navicular stress fracture
Defensive lineman with vague, persistent foot pain

Tarsal navicular stress fracture
Defensive lineman with vague, persistent foot pain

Tarsal navicular stress fracture
Defensive lineman with vague, persistent foot pain

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5th Metatarsal Stress Fracture

- Zone 3
  - In the distal metaphysis at the metadiaphyseal junction
- Usually a stress fracture
- SLC for 6-8 weeks
- WB status is controversial
- Nonunions: IM screw fixation

Stress Fracture

Figure 6

Bipartite sesamoid or fracture?

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Summary
- The majority of stress fractures can be managed non-operatively with activity modification and casting/bracing if necessary
- Identify the "low risk" from the "high risk"
- H and P should guide to correct diagnosis. Avoid misdiagnosis... e.g. osteosarcoma
- DDx: Apophysitis in skeletally immature, "shin splints"
- Remember can always image the unaffected side for comparison...
- Don't forget to look for dietary and hormonal causes, especially in female athletes and vitamin D deficiency
- When in doubt, refer to orthopedic colleague

Bibliography
- Delee and Drez's Orthopedic Sports Medicine, 2nd edition
How to avoid stress in general
Thank You