Fatigue Fracture

-with focus on proximal tibial pain of young athletes

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**Stress fracture: Definition & Classification**

- **Definition:**
  - Partial or complete fracture of bone due to inability of the bone to withstand non-violent stress which is applied in a rhythmic, sub-threshold manner.

- **Classification:**
  - **Fatigue fracture**
    - Prolonged, cyclic mechanical stresses on normal bone
  - **Insufficiency fracture**
    - Physiologic stress on bone weakened by metabolic disease or radiation treatment
Fatigue fracture: Clinical features

• History:
  – Prolonged periods of unaccustomed or strenuous activities
  – Localized pain exacerbated by activities, relieved by rest and reoccurs when activity is restarted.

• Physical findings:
  – Localized tenderness, redness warmth & swelling.
Fatigue fracture: Epidemiology

- Commonly affected group:
  - Athlete & military recruits

- Commonly affected area:
  The lower extremities
  - Diaphysis of Tibia: 50%
  - Fibula: 20%
  - Pars interarticularis of lumbar spine: 15%
  - Femur: 3%
  - Metatarsals: 2%
  - Tarsal navicular: 2%

From Datir, A.P., A. Saini, A. Connel, A. Saifuddin. Stress-related bone injuries with emphasis on MRI. *Clinical radiology* 2007; 62: 828-36
Fatigue fracture: Differential diagnosis

• Diseases needed to be differentiated with:
  – Muscle sprain
  – Insufficiency fracture
  – Osteoid osteoma
  – Osteomyelitis
  – Neoplasm
  – Osteomalacia
  – Ligamentous injury with secondary osseous reaction
The diagnostic pitfalls of Fatigue fracture

• Careful history taking & proper physical examination are important in establishing the diagnosis

• However,
  – The symptoms may mimic other musculoskeletal complaints, and follow-ups are required.
  – The delay of a proper diagnosis may cause catastrophic fracture & surgical intervention

• Hence, it is important to know how to use different imaging modality in confirming diagnosis.
Fatigue fracture: Image modality

- Plain radiography
- Computed tomography (CT)
- Magnetic Resonance Imaging (MRI)
- Bone scintigraphy
Plain Radiography - Advantages & Disadvantages

• Primary tool for stress injury imaging:
  – cheap
  – widely available

• Disadvantage:
  – insensitive in early stage:
    • the time from onset of pain to positive radiographic finding varies from 2 wks to 3 months.
    • Up to 85% of fatigue fractures are overlooked on the first radiograph.
  – limited usefulness in late phase
Plain Radiography – Image Findings

• Possible findings:
  – Cortical thickening
    • Endosteal reaction
    • Benign periosteal reaction
  – Fracture line
    • Not always seen
  – Callus formation
  – Bone sclerosis

Sequential Radiography

- **Sequential radiograph** may help differential diagnosis
  - The abnormal findings become more obvious as time goes by

CT — Advantages & Disadvantages

• Advantage:
  – Good at detection of discrete lucent, sclerotic fracture line or periosteal reaction
    – differentiating osteoid osteoma from stress fracture,
    – pediatric stress fracture, pars-interarticular or navicular fracture

• Disadvantage:
  – Radiation exposure

• Indication:
  – suspected fracture at specific sites
  – patients have contraindication for MR imaging
  – equivocal finding on radiography, MRI or scintigraphy
CT– Image findings

• Possible findings:
  – Cortical thickening
    • Endosteal reaction
    • Benign periosteal reaction
  – Fracture line
    • Not always seen
  – Bone sclerosis
  – Callus formation

Bone Scintigraphy – Background

• Mechanism:
  – Detect the increased bone metabolism & osteoblastic activities while bone remodeling

• Three-phase technique:
  – Blood flow phase
  – Soft tissue phase
  – Delayed skeletal phase
    • Differentiate soft tissue injury from osseous injury

• Fatigue fracture shows increased tracer uptake in all the three phases

Bone Scintigraphy – Image findings

- Typically, demonstrate abnormality 2 weeks or more before plain radiography.

A abnormal, increased uptake in calcaneous on Bone scintigraphy

Several wks later

A sclerotic line in posterior calcaneous on Radiograph

Bone Scintigraphy –
Advantages & Disadvantages

• Advantages:
  – High sensitivity (~ 100%)
  – Early detection
    • Show abnormality within 6-72 hrs after the onset of symptom
    • Prevent progression, protracted disability and complication

• Disadvantage:
  – Low specificity
  – Limited follow-up utility
    • Abnormal uptake may persist for several months.
  – Invasiveness
  – Lack immediate availability
**MRI – Advantages**

- **The Gold standard for evaluation of fatigue fracture**
- **Advantage:**
  - Early detection
  - High sensitivity & specificity
  - Compared with Bone scintigraphy:
    - Non-invasive, no ionizing radiation
    - More precise anatomic localization
    - More rapidly performed
    - Some reference suggested that MRI is more sensitive than Bone scan (reference 22. Gaeta M. & 42. Kiuni MJ.)
MRI – Disadvantages

• Disadvantage:
  – Expensive
  – Too exquisite detail
    • should always make diagnosis with clinical history.
  – Lack immediate availability
  – Inability to image cortical bone to a significant degree
MRI — Image findings

- Possible findings:
  - Bone marrow edema
  - Soft tissue edema
  - Fracture line

After knowing more about fatigue fracture, it is time to meet our patients
Index Patient — Present illness

- BD, a 21-yr-old man, presented with **right proximal tibial pain** for 4-5 months
  - An **athlete**: runner & karate instructor
  - Insidious onset
  - **Activity-related** pain
  - Acetaminophen & NSAID (Ibuprofen) could relieve the pain
  - No prior trauma history
  - No neurological abnormalities
Index Patient — More medical history

• Past medical & surgical history:
  – none

• Current medication:
  – none

• Family history:
  – significant for colon cancer & DM

• Social history
  – No smoking
  – Alcohol drinking

• Drug & Food allergy:
  – none

• Review of system:
  – non-contributory
Companion Patient — Present illness

- AH, a 18-yr-old man, had **left tibia pain** 2 years ago
  - Proximal medial tibia
  - Mid third lateral tibia
  - A **athlete**: middle-distance-track runner
  - Insidious onset
  - Pain **aggravated by activities**, relieved by rest
  - NSAID (Ibuprofen) could relieve the pain
  - Pain is also **more severe at night**
Companion Patient – More medical history

- Past medical & surgical history:
  - none
- Current medication:
  - Claritin for seasonal allergy
- Family history:
  - Lung cancer, throat cancer & heart disease
- Social history
  - Graduate student
  - No smoking, but sometimes drink alcohol.
- Drug & Food allergy:
  - Amoxicillin (rash)
- Review of system:
  - non-contributory
Comparison of our Patients

• **Similarity:**
  – Young athlete
  – Activity-associated tibia pain
  – NSAID could relieve the pain
  – No prior trauma history
  – Unremarkable past medical history & family history

• **Differences:**
  – Companion Patient:
    pain sometime became more severe at night
Differential list of our Patients

• Fatigue fracture
• Osteoid osteoma
  – Typical triad:
    pain, worse at night, could be relieved by NSAID
  – A radiolucent nidus with surrounding cortical thickening in the metaphysis or diaphysis of tibia or femur.
• Osteomyelitis
  – No systemic symptoms
  – No possible infection etiology
• Neoplasm
Plain Radiography –
Index & Companion Patients

• Image findings:
  – Benign periosteal thickening
  – No obvious fracture line
    or radiolucent nidus was seen

• No diagnostic findings
  were found.

On the courtesy of Dr. Jim Wu, BIDMC
MRI – Index patient

- Image findings:
  - Cortical thickening
  - Bone marrow edema
    - Low attenuation in T1
    - High attenuation in STIR
  - Soft tissue swelling
  - No soft tissue mass
  - No obvious fracture line was noticed
MRI – Companion patient

- Image findings:
  - Cortical thickening
  - Bone marrow edema
    - Low attenuation in T1
    - High attenuation in STIR
  - Soft tissue swelling
  - No soft tissue mass
  - No obvious fracture line was noticed

T1, Coronal view of left tibia, C-
STIR, Coronal view of left tibia, C-

On the courtesy of Dr. Jim Wu, BIDMC
Primary Diagnosis of our patients

• Based on their history & primary image studies:
  – Differential diagnosis:
    • Fatigue fracture
    • Osteoid osteoma
    • Neoplasm
      – No aggressive periosteal reaction
      – No soft tissue mass
    – **Fatigue fracture** was highly suspected
    – Temporary rest and 6-wk-follow up were suggested
1st Follow-up of our patients

- After 6-week-rest
- Index patient
  - Symptoms improved, but not good enough

- Companion patient
  - Mid-third lateral tibia: Improved
  - Proximal medial tibia
    - Persistent aching pain
    - More severe at night

- Under the suspicion of Osteoid osteoma, **Computed Tomography** was prescribed for further evaluation.
CT – Index patient

• Image findings:
  – Curvilinear lucent fracture line in the cortex
  – Periosteal reaction
    • Cortical thickening
  – No associated soft tissue mass or change.

• Symptoms and findings were compatible with Fatigue fracture

Axial view of right proximal tibia & fibula, C-

On the courtesy of Dr. Jim Wu, BIDMC
CT – Companion patient

• Image findings:
  – Oval-shaped radiolucent lesion in the cortex
  – Periosteal reaction
    • Cortical thickening
  – No significant soft tissue mass or change

• Symptoms and findings were compatible with Osteoid osteoma

Axial view of left proximal tibia & fibula, C-

On the courtesy of Dr. Jim Wu, BIDMC
From the CT images, we can clearly tell the difference between both patients and gave them more appropriate treatment according to their diagnosis.
Treatment:
Fatigue fracture vs. Osteoid osteoma

- **Index patient**
  - Diagnosis: **Fatigue fracture**
  - Further rest with regular follow-up were suggested

- **Companion patient**
  - Diagnosis: **Osteoid osteoma**
  - Biopsy was done to confirm the diagnosis
  - After discussion, radiofrequency ablation was decided
2nd Follow up of index patient: Fatigue fracture

- After 6-weeks-rest
  - Symptoms improved a lot
    - No pain even with some activities
    - Only mild tenderness when palpated

- Plain radiography:
  - Cortical thickening
  - Fracture line with sclerosis
  - No evidence of soft tissue mass
3rd Follow up of index patient: Fatigue fracture

• After another 3 months
  – No obvious symptoms
    • No pain while palpation or with normal activities in daily life
  – Conventional radiography:
    • Fracture line was no longer visible
    • Periosteal & Endosteal thickening
    → Steady healing process was noticed

Frontal view of right proximal tibia

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Take home message

• The diagnosis of stress fracture is established at
  – Thorough clinical history-taking
  – Careful physical examination
  – Multiple imaging modality

• Different modality offer different information regarding the disease.
  – Understand the strength & weakness of each modality
  – Choose the most appropriate one wisely without misleading ourselves or unnecessary treatment
References

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