



Atlantic Sports Health

ATLANTIC HEALTH SYSTEM

# Stress Fractures

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# Objectives

- Identify the most important risk factors for stress fractures
- Recognize stress injuries based on history and clinical presentation
- Differentiate between high risk and low risk stress fractures
- Be able to formulate an initial management plan for stress injuries



# Outline

- Background
- Risk Factors
- Physical Exam
- Imaging
- High Versus Low Risk Stress Fractures
- Treatment
- Prevention
- Cases



# Definition

- First described in 1855 as a common overuse injury in athletes and military recruits
- A stress fracture is a fatigue fracture of bone caused by repeated submaximal stress
- 10% of all overuse injuries in sport
- Up to 20% of all sports medicine clinic injuries may be related to stress injuries

Martinez et al. Stress Fractures. Medscape May 2015.

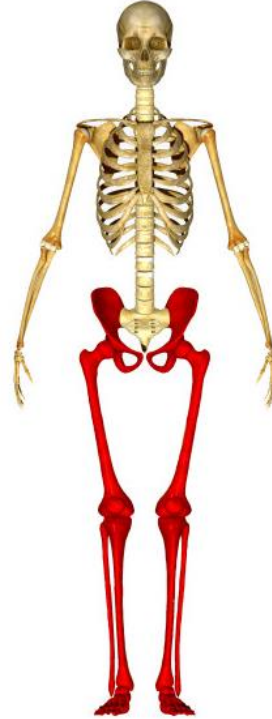
Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174

McCinnis et al. High risk stress fractures: diagnosis and management. PMNR 8 (2016) S113-S124

Kiel J et al. Stress reaction and fractures. StatPearls Publishing, June 4 2019



# Location of Stress Fractures



- 95% occur in the lower extremity
- 69% occur in Runners

Martinez et al. Stress Fractures. Medscape May 2015.

Denay K. Stress Fractures. Current Sports Medicine Reports. Vol 16 (1), Jan 2017



# Location of Stress Fractures



- Tibia 23.6%
- Tarsal Navicular 17.6%
- Metatarsal 16.2%
- Fibula 15.5%
- Femur 6.6 %
- Pelvis 1.6 %



- Incidence and prevalence of stress fractures in children is not well described



# What athletes are at risk?

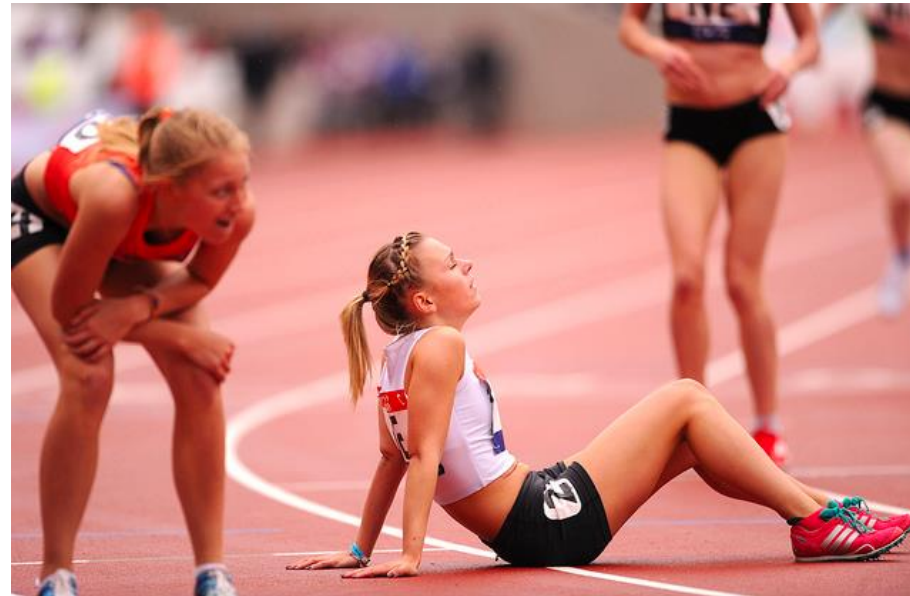
- Repetitive, high-intensity training





# Athletic Population

- Fatigued muscles subject the bone to increasing force, which may contribute to the overloading process



Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174



# Location of Stress Fracture By Sport

LOCATION	SPORT
Metatarsals	Football, basketball, gymnastics, ballet
Sesamoids of the foot	Running, ballet, basketball, skating
Navicular	Basketball, football, running
Talus	Pole Vaulting
Fibula	Running, aerobics, ballet
Tibia	Running, sports, dancing, ballet
Patella	Running, hurdling
Femoral Neck	Distance running
Pubic Rami	Distance Running
Pars Articularis	Gymnastics, ballet, cricket, volleyball, diving, football
Chest, ribs	Swimming, golf, rowing
Ulna	Racquet sports, volleyball
Olecrenon	Baseball, throwing sports





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- Risk factors for stress fractures are similar for both children and adults



# Risk Factors

## Intrinsic

- Female
- Amenorrhea
- Low BMD
- Genu Valgus
- Leg length discrepancy
- Poor aerobic fitness at onset of exercise

## Extrinsic

- Rapid progression of training
- Poor surface
- Running and Jumping sports
- Poor footwear
- Smoking
- Poor nutrition

Henning P, The running athlete. Stress fractures, osteitis pubis, and snapping hips. Sports Health 2014 Vol 6(2) 122-127

Saunier J. et al. Stress fractures in athletes. Joint Bone Spine 85 (2018) 307-310.



# Risk Factors

## Intrinsic

- Pes Planus
- Pes Cavus
- Stiff Joints
- Ligamentous Laxity
- Low Testosterone (males)

Henning P, The running athlete. Stress fractures, osteitis pubis, and snapping hips. Sports Health 2014 Vol 6(2) 122-127

Mayer et al. Stress fractures of the foot and ankle in athletes Sports Health 2014 Vol 6(6) 481-491

Patel, D et al. Stress fractures: Diagnosis, Treatment, and Prevention. American Family Physician Vol 83(1), Jan 2011.

## Extrinsic

- Inadequate rest periods
- >10 alcoholic beverages per week



# Sex-Specific Risk Factors For Stress Fractures in Adolescent Runners



- Tenforde, A. et al 2013
- Study: Prospective Design
- N = 748 competitive high school runners (442 girls and 306 boys)
- Mean age 15
- Athletes followed for approx 2 seasons





# Sex-Specific Risk Factors For Stress Fractures in Adolescent Runners

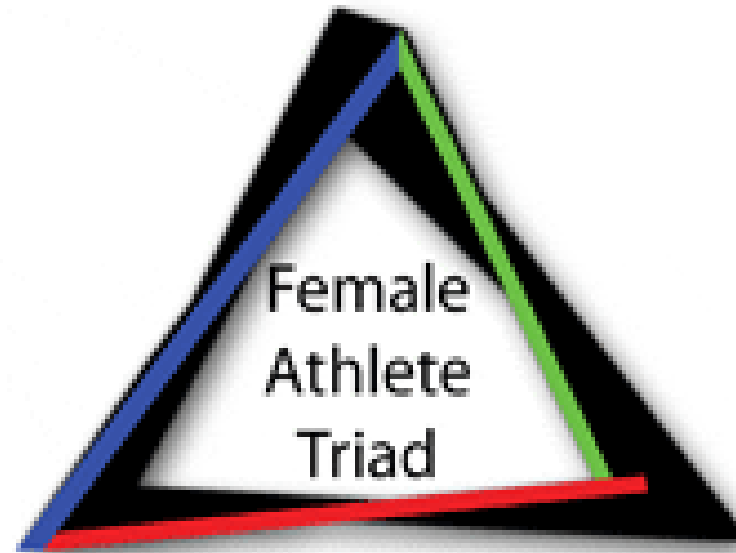
## Results:

- Stress fractures in female runners may be more likely in athletes with **BMI <19, late menarche (15 or older), history of participation in gymnastics or dance, prior stress fracture**
- Stress fractures in male runners may be more likely in athletes with **a prior stress fracture**
- Basketball may be protective in males



# Female Athlete Triad

Low Energy Availability/Disordered Eating



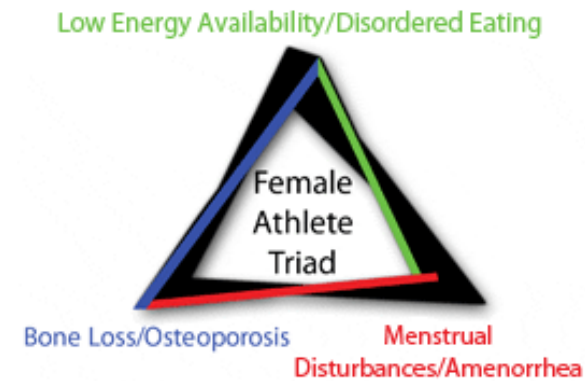
Bone Loss/Osteoporosis

Menstrual  
Disturbances/Amenorrhea

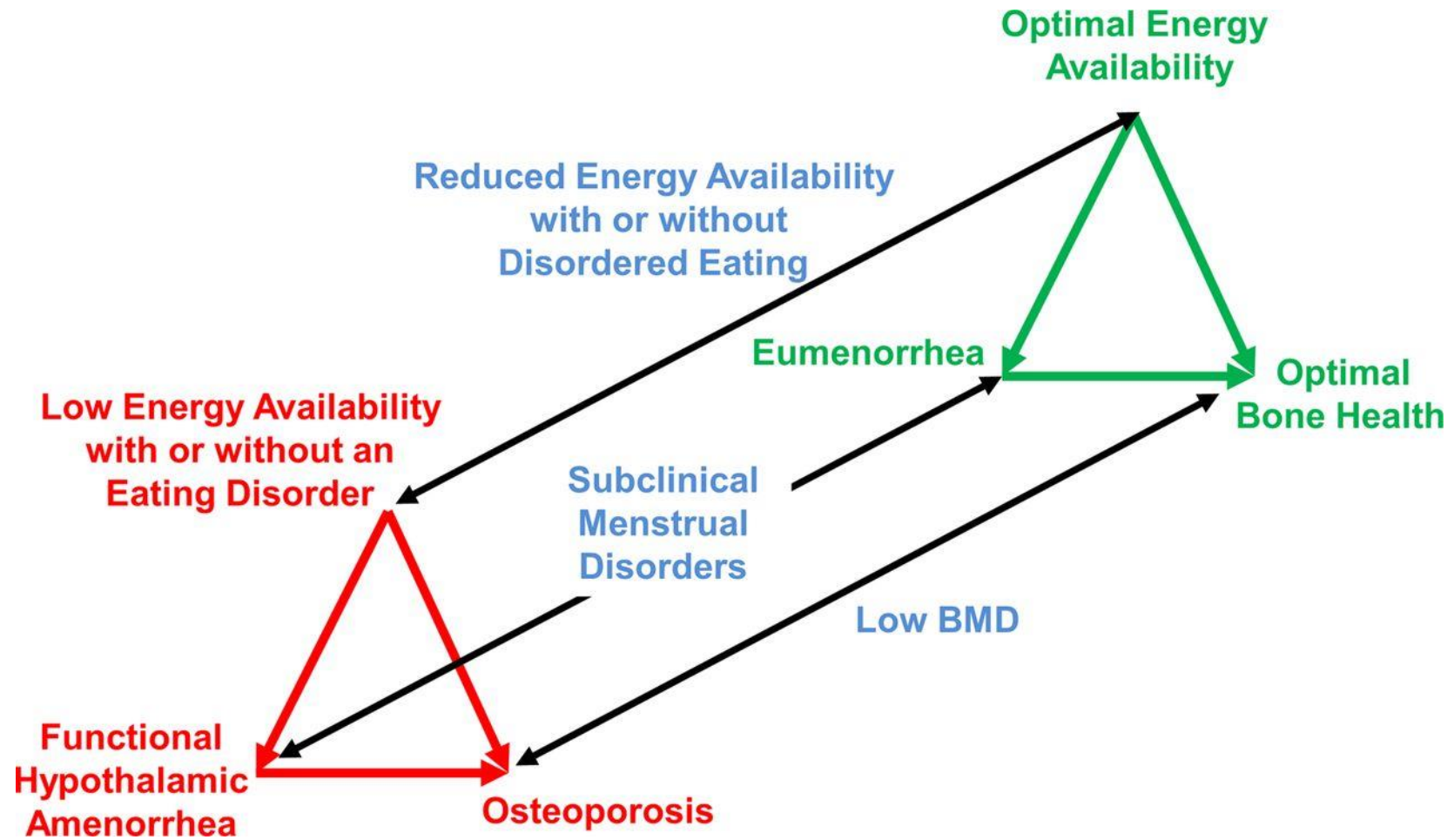


# Female Athlete Triad

- Medical condition observed in physically active girls and women and involves any ONE of the three components:
  - 1) Low energy availability with or without disordered eating
  - 2) Menstrual dysfunction
  - 3) Low bone mineral density



# Spectra of the Female Athlete Triad.



Mary Jane De Souza et al. Br J Sports Med 2014;48:289



# Why Screen?

- 1) Early Intervention
- 2) 90% of peak bone mass is attained by 18 years of age



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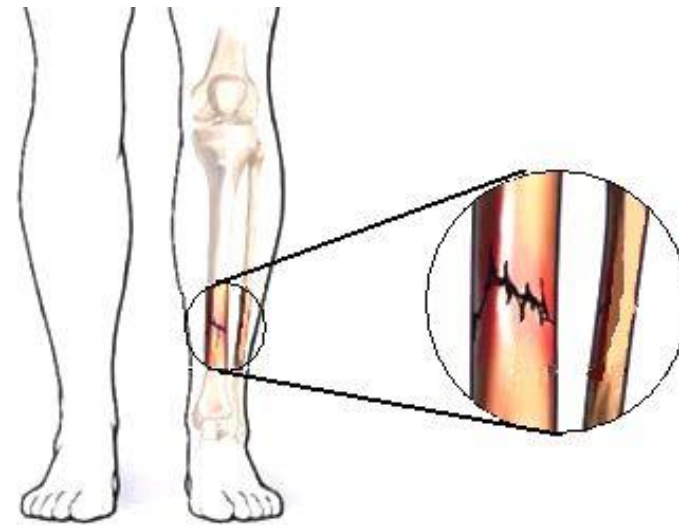
# Diagnosis

- History – Pain with activity, progressive in nature
- History – Review all potential risk factors
- History – Previous Stress Fracture
- Physical Exam
- Imaging



# Physical Exam

- Local tenderness (65.9% to 100%)
- Swelling (18-44%)
- Warmth
- Palpable Callus
- Range Of Motion
- Special tests



Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174

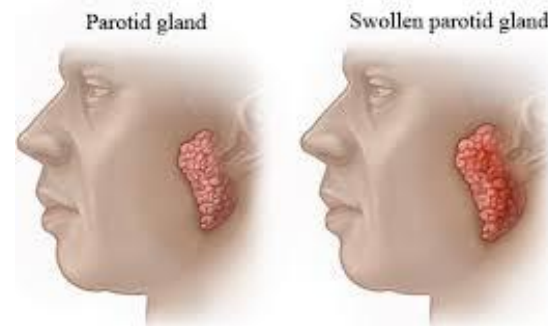
Patel, D et al. Stress fractures: Diagnosis, Treatment, and Prevention. American Family Physician Vol 83(1), Jan 2011.





# Physical Exam Signs Of The Female Athlete Triad

- 1) Low BMI
- 2) Weight loss
- 3) Orthostatic Hypotension
- 4) Lanugo
- 5) Hypercarotenaemia, parotid gland swelling
- 6) Russel sign (callus on your knuckles)



# Fulcrum Test



Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174



# Faber



Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174

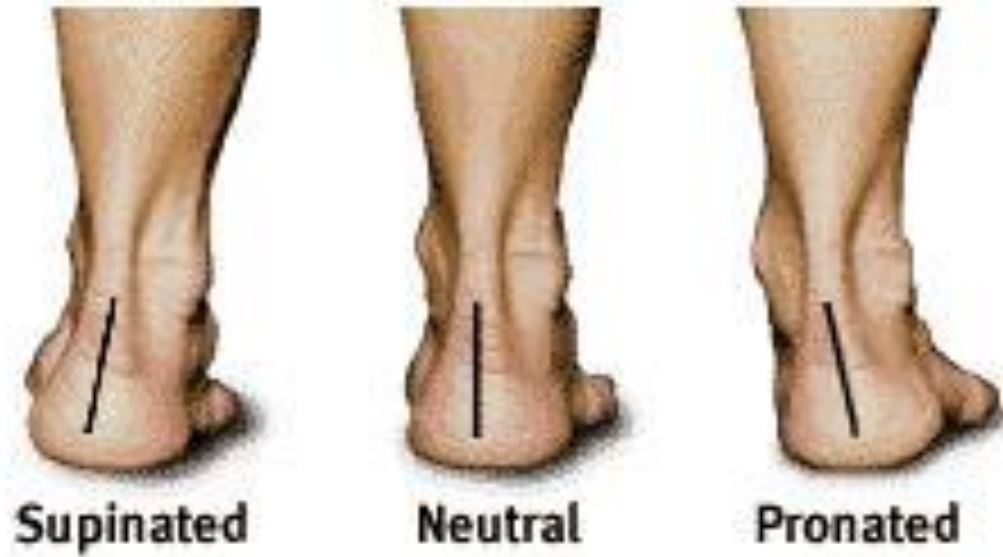


# Flamingo Test



Behrens et al. Stress fractures of the pelvis and legs in the athlete: a review . Sports Health 2013 Vol 5(2) 165-174





# Leg Length Discrepancy



# Hop Test

- 70% positive medial tibia stress fracture
- 50% positive with medial tibial stress syndrome



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Saunier J. et al. Stress fractures in athletes. Joint Bone Spine 85 (2018) 307-310.



# Tuning Fork



- Sensitivity 75%, Specificity 67%

Patel, D et al. Stress fractures: Diagnosis, Treatment, and Prevention. American Family Physician Vol 83(1), Jan 2011.

Saunier J. et al. Stress fractures in athletes. Joint Bone Spine 85 (2018) 307-310.





# Humeral Squeeze Test



Zaremski, J et al. Humeral Stress Fractures in Overhead Athletes: Pearls for Recognition, Diagnosis, and Management. *Curr Sports Med Rep.* 2016; 15 (6): 384-385.



# Therapeutic Ultrasound



- Therapeutic ultrasound adjunct to physical exam
- 2012 study found increased pain with application of therapeutic ultrasound at the site of a stress injury to have a PPV 99%(sensitivity, 81.8%; specificity 66.6%)



# The ability of clinical tests to diagnose stress fractures

- Schneiders, A et al.
- Study Design: Systemic literature review and meta-analysis
- Diagnostic accuracy studies between 1950-2011
- Evaluated clinical tests against a radiologic diagnosis of stress fractures
- Evaluated therapeutic Ultrasound and Tuning Fork



# The ability of clinical tests to diagnose stress fractures

## Results

- Pooled sensitivity of Ultrasound 64% (95% confidence interval [CI]: 55%, 73%), specificity of 63% (95% CI: 54%, 71%), positive likelihood ratio of 2.1 (95% CI: 1.1, 3.5), and negative likelihood ratio of 0.3 (95% CI: 0.1, 0.9).
- Tuning fork test data could not be pooled; however, sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio ranged from 35% to 92%, 19% to 83%, 0.6 to 3.0, and 0.4 to 1.6, respectively.



# The ability of clinical tests to diagnose stress fractures

## Conclusion

- The results of this systematic review **do not support** the specific use of ultrasound or tuning forks as standalone diagnostic tests for lower-limb stress fractures



# “Shoe Test”





# Differentials

- Tendinopathy
- Compartment Syndrome
- Nerve or artery entrapment
- Medial Tibial Stress Syndrome (shin splints)
- Malignancies





# Medial Tibial Stress Syndrome



The patient with MTSS will exhibit tenderness along the distal two thirds of the medial tibial border (indicated in the orange shading).



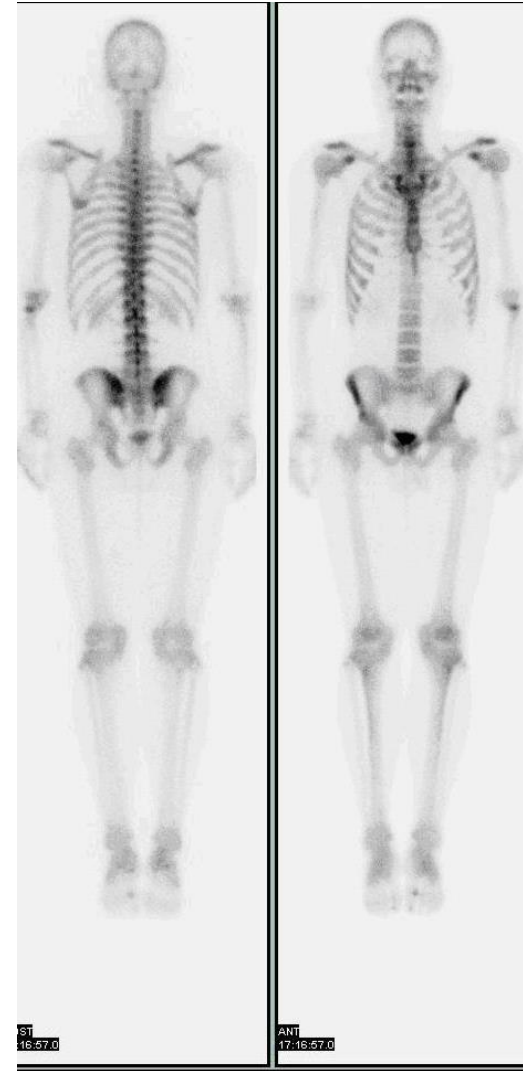
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# Imaging

- X-rays (sensitivity 10%)
- MRI (sensitivity 86% to 100%)
- CT is useful for stress fractures in the pelvis and sacrum (not well visualized by MRI) or to better visualize questionable fractures
- Bone Scan (sensitivity 74%-84%) but non specific



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Patel, D et al. Stress fractures: Diagnosis, Treatment, and Prevention. American Family Physician Vol 83(1), Jan 2011.



# Radiologic Grading Of Stress Fractures

Grade	X-Ray	MRI
0	Normal	Normal
1	Normal	Positive STIR
2	Normal	Positive STIR and T2 images
3	? Discrete Line	Positive T1 and T2 images
	? Discrete Periosteal Reaction	Without definite cortical fracture
4	Fracture	Positive T1 and T2 fracture line
	Periosteal Reaction	

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# Stress Fracture Risk of Delayed Union

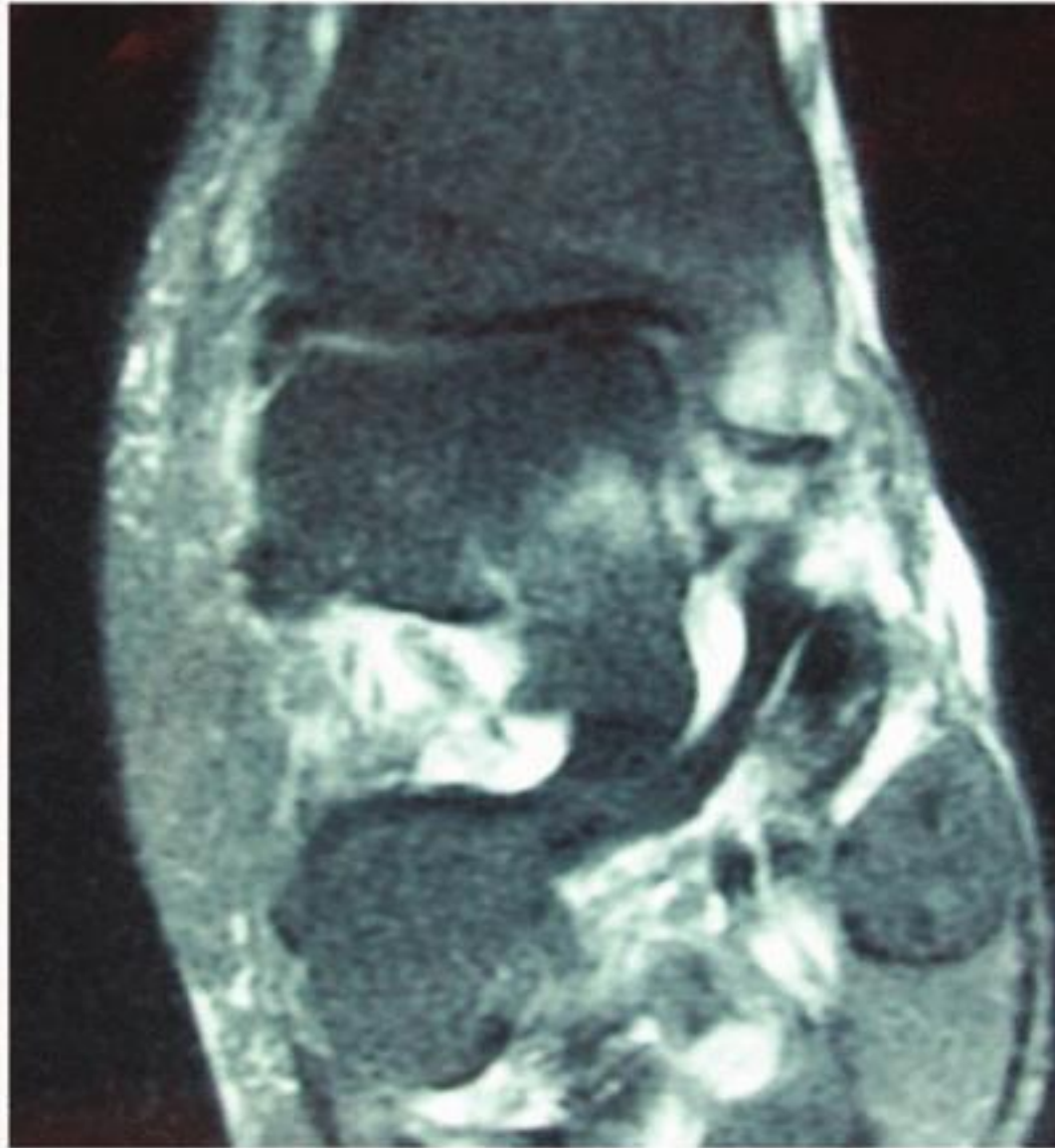
High Risk	Low Risk
Anterior tibial diaphysis	Posteromedial Tibia
Lateral Femoral Neck	Metatarsals
Patella	Calcaneous
Medial Malleolus	Cuboid
Navicular	Cuneiform
Fifth Metatarsal	Fibula
Proximal Second Metatarsal	Medial Femoral Neck
Sesamoids	Femoral Shaft
Talus	Pelvis
Femoral Head	

## Maximal Tensile load in a zone of diminished blood flow

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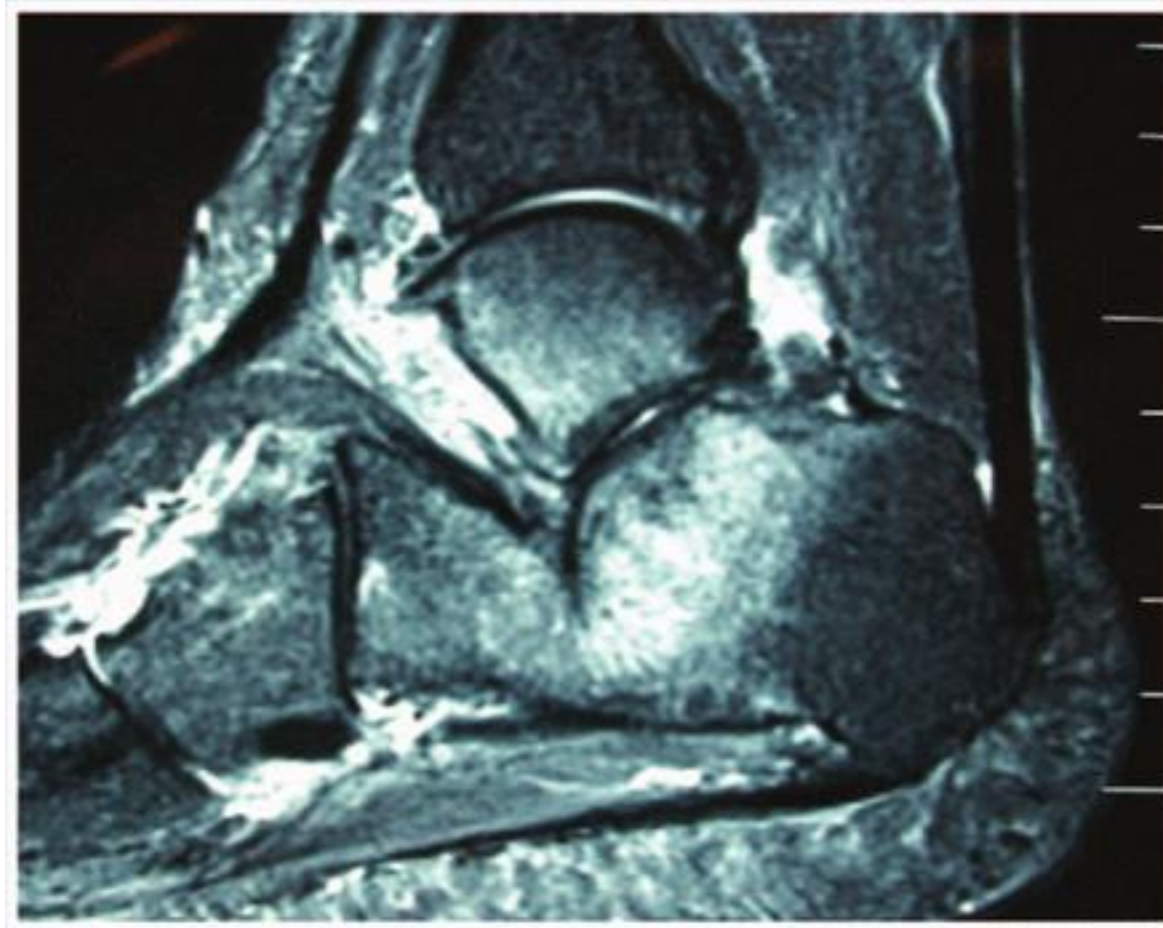
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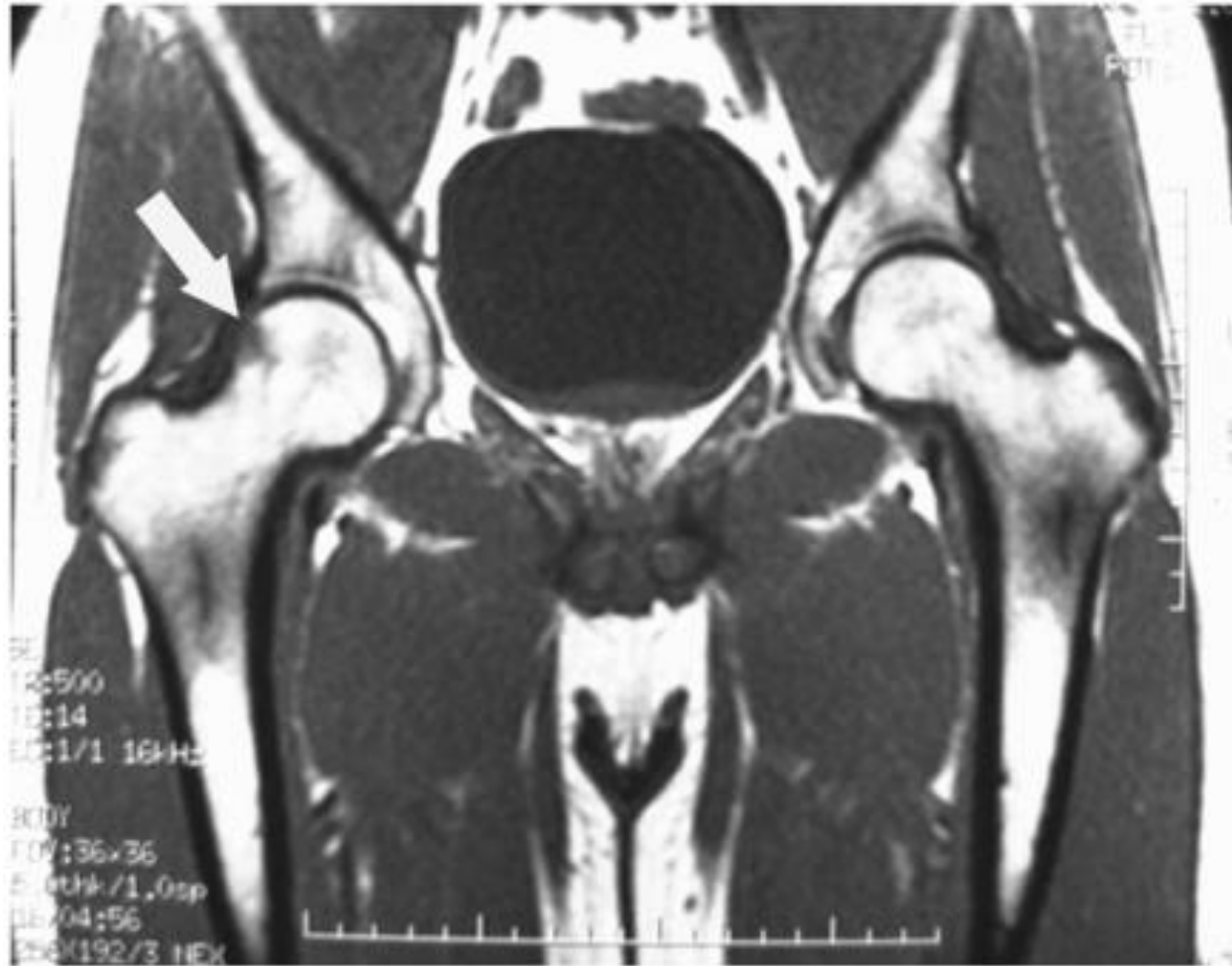






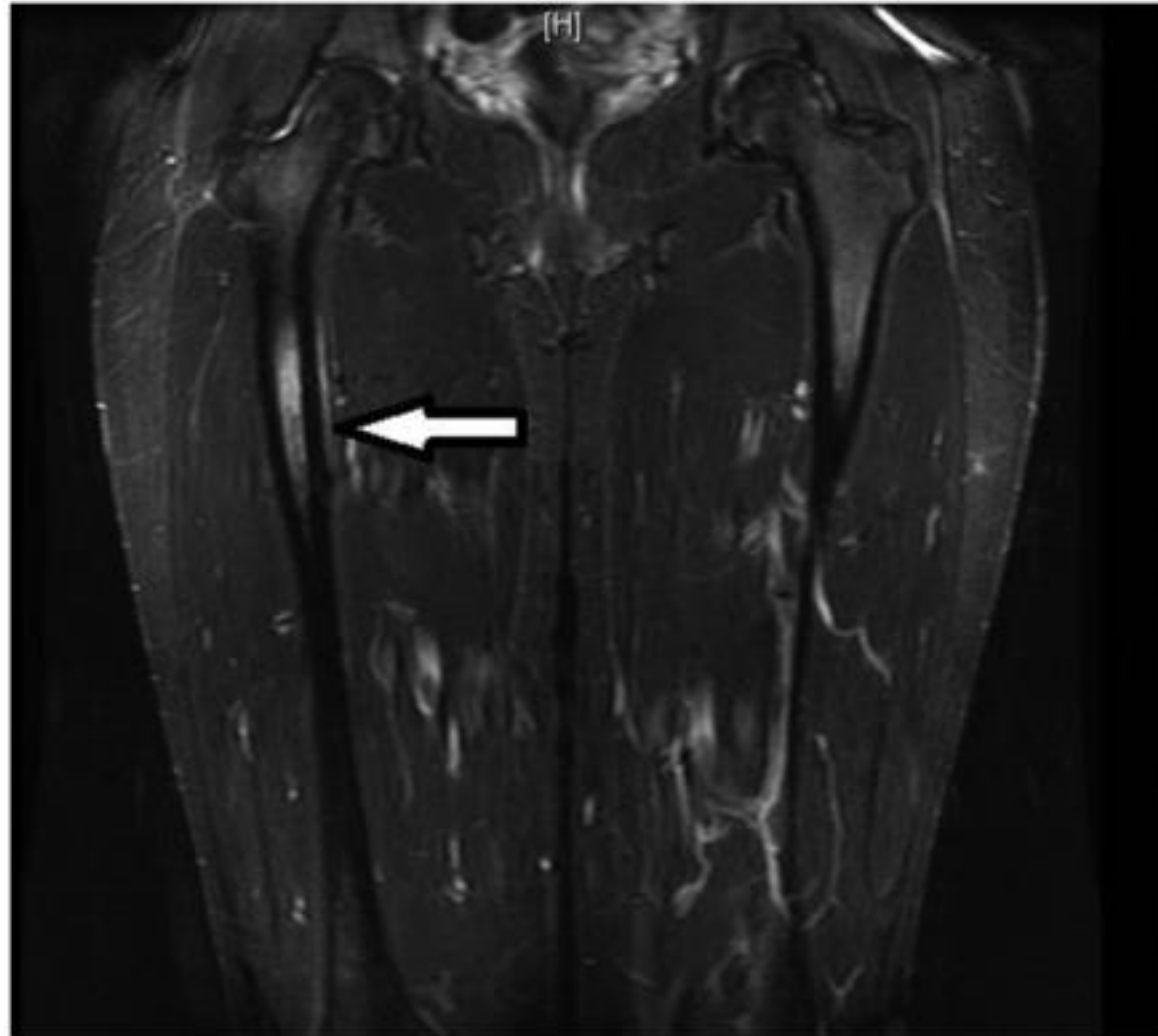
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# Treatment

- Rest from inciting event (4-12 weeks or longer)
- +/- Immobilization
- Pain free functioning
- Treat underlying condition i.e Female Athlete Triad
- NSAIDS – avoid ? animal studies delayed stress fracture healing, however, meta-analysis showed no delayed healing
- Other Medications
- Bone stimulators



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Patel, D et al. Stress fractures: Diagnosis, Treatment, and Prevention. American Family Physician Vol 83(1), Jan 2011.





# Treatment

- Bisphosphonates
- Decrease bone turnover by inhibiting osteoclast function
- Prospective Study 324 military recruits
- Prophylactic dose of risedronate showed no difference in i.e. stress fractures versus placebo



# Treatment

- Female Athlete Triad Expert Panel emphasized caution when using FDA approved postmenopausal treatment strategies for use in premenopausal women and children



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# Oral Contraceptives

- Overall, investigators have shown that oral estrogen-progesterone combination pills are not an effective strategy to increase BMD in low-weight conditions such as anorexia nervosa (both in adults and in adolescents).<sup>167,168</sup> Studies of COCs or hormone therapy in athletes with FHA are less definitive



# Treatment of Female Athlete Triad

- Expert Panel agreed non-pharmacologic therapy is the mainstay of treatment for all athletes with 1 or more component of the triad




# Vitamins

- Calcium rich foods, calcium intake between 1000 and 1300 mg/d
- Vitamin D 600 IU a day
- Female Athlete Triad Coalition Panel recommended that vitamin D levels be maintained between 32 and 50ng/dl
- Calcium and vitamin D can improve BMD but are not definitely proven to prevent stress fractures



# Bone Stimulators

- 2 types electromagnetic and ultrasound stimulators
  - Electromagnetic – lead to cell proliferation
  - Pulsed Ultrasound - angiogenesis
- VEGF and FGF which promote
- 



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# Prevention

- There are no studies specifically on prevention of stress fractures in the pediatric and adolescent population.
- However, since the risks factors are generally the same as in adults, it is reasonable to employ the same prevention strategies
- Including setting limits on impact activities, optimizing Vitamin D and calcium intake, screening for the female athlete triad, and considering the use of shoe orthotics.





# Screening for the Triad

- Current PPE – 9 questions related to the PPE
- Consensus panel recommends annual screening with the the Triad-specific self report questionnaire



# Triad Consensus Panel Screening Questionnaire

- Have you ever had a menstrual period?
- How old were you when you had your first menstrual period?
- When was your most recent period?
- How many periods have you had in the past 12 months?
- Are you presently taking any female hormones (oestrogen, progesterone, birth control?)
- Do you worry about your weight?



# Triad Consensus Panel Screening Questionnaire

- Are you trying to or has anyone recommended that you gain or lost weight?
- Are you on a special diet or do you avoid certain types of foods or food groups?
- Have you every had an eating disorder?
- Have you every had a stress fracture?
- Have you ever been told you have low bone density?



# Prevention

- Few validated studies
- Screen for female athlete triad
- Modification of training schedules
- Follow Pediatric Exercise Guidelines
- Orthotics
- Calcium, Vitamin D, nutrition
- Strengthening of affected extremities
- Good equipment
- Staying in the pain free zone
- Assessing abnormal biomechanics?



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# Case 1

- 14 year old Caucasian soccer player presents with a two week history of right knee pain, coincided with a sudden increase in running and conditioning
- Denies any trauma or injury
- PMH: RA, treated with methotrexate for several years, however, switched to Humira this year, no stress fracture history
- Exam: BMI 17, pain medial femoral chondyle, medial joint line, no swelling, no erythema, +fulcrum test, +hop test, pes planus and pronation on gait analysis



# X-ray



Shutter



# X-ray



Shutter

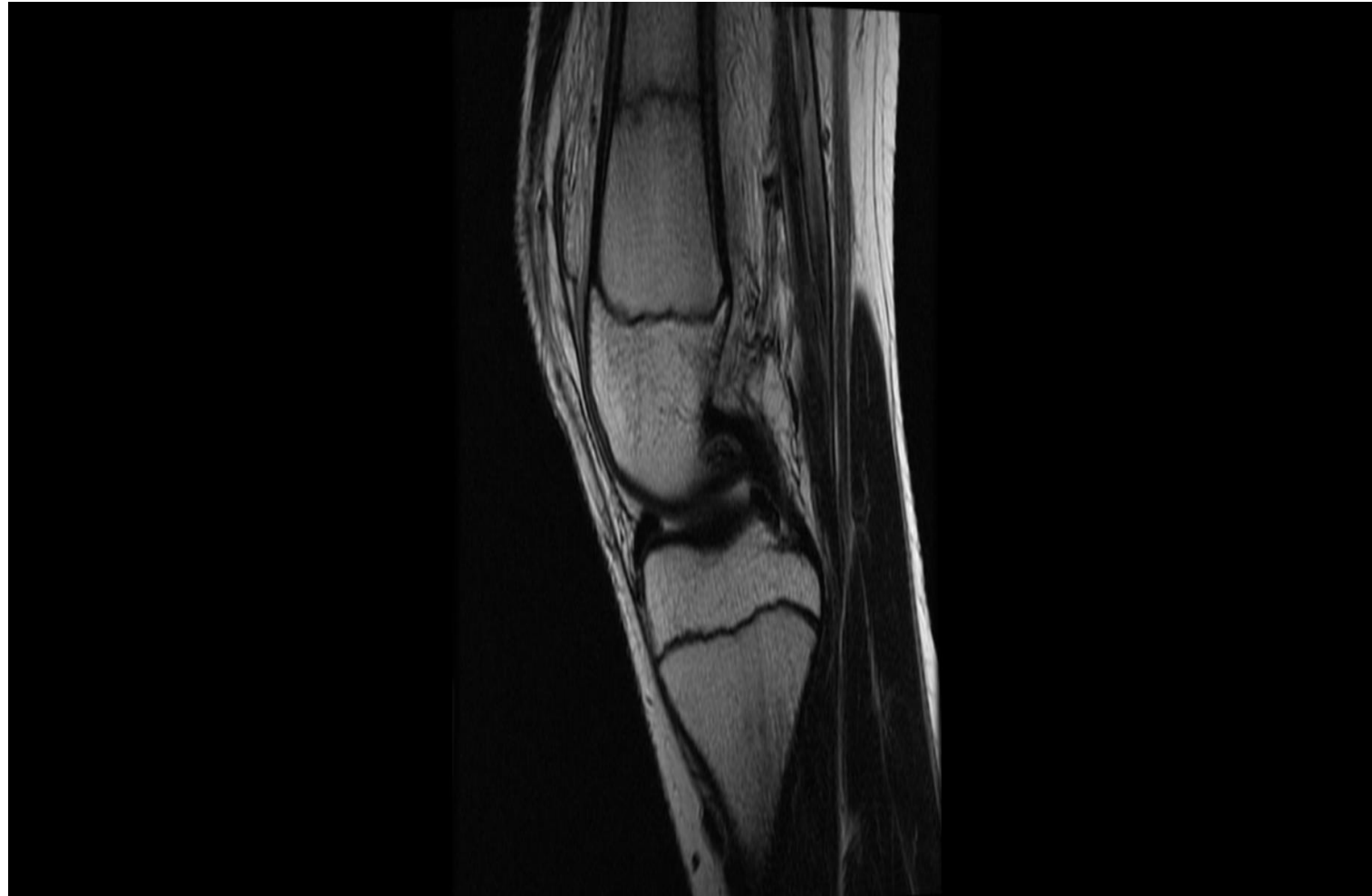




# MRI



# MRI



## Case 2

- 16 year old African American female cross country athlete presents to the office with a several month history of right sided shin pain
- Denies any trauma or injury
- PMH: no previous fracture
- Exam: BMI 23, pain anterior tibia, diffusely along posterior medial tibia, +hop test, significant pes planus and pronation



# X-ray



# X-ray





# Post-Op



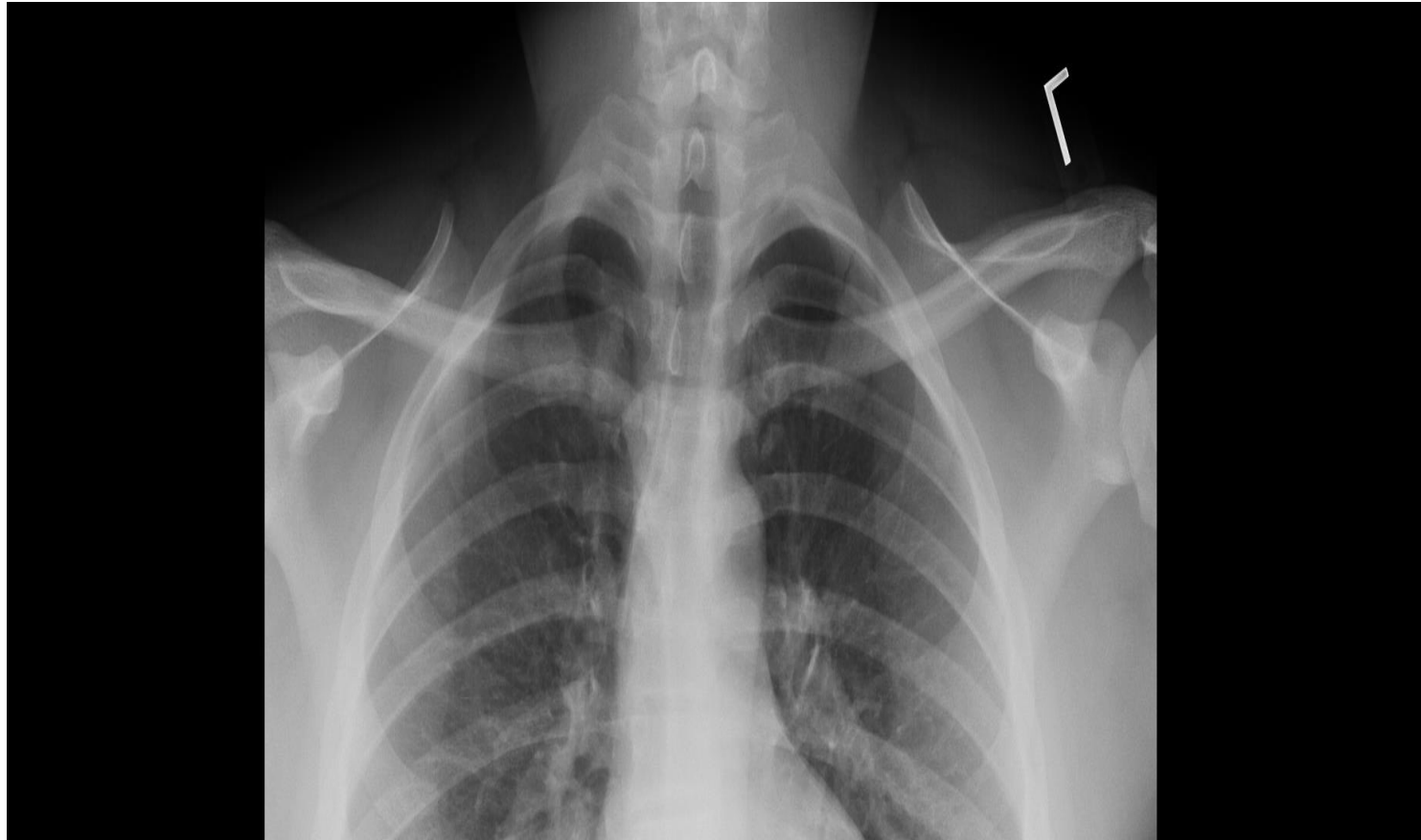
# Case 3

- 17 year old football player presents with a 3 week history of non-specific left sided chest and back pain while in the weight room, he was a lineman and did not remember any trauma to the area
- PMH: no previous fracture
- Exam: Diffuse pain over his left anterior chest, also in his trapezius





# X-ray



# Conclusions

- Have a high sense of suspicion based on history of risk factors
- Physical exam is limited in terms of sensitivity
- Recognize your high risk stress fractures and refer to ortho/sports medicine
- X-rays are not good, MRI if you suspect
- Start treatment by eliminating activity, modify weight bearing



# Thank You

