

Diagnostic Imaging Pathways - Stress Fracture (Suspected)

Population Covered By The Guidance

This pathway provides guidance on the imaging of adult patients with suspected stress fractures.

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Date of next review: 2017/2018

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Quick User Guide

Move the mouse cursor over the **PINK** text boxes inside the flow chart to bring up a pop up box with salient points.

Clicking on the **PINK** text box will bring up the full text.

The relative radiation level (RRL) of each imaging investigation is displayed in the pop up box.

SYMBOL	RRL	EFFECTIVE DOSE RANGE
	None	0
	Minimal	< 1 millisieverts
	Low	1-5 mSv
	Medium	5-10 mSv
	High	>10 mSv

Pathway Diagram

Date reviewed: August 2013
Please note that this pathway
is subject to review and
revision

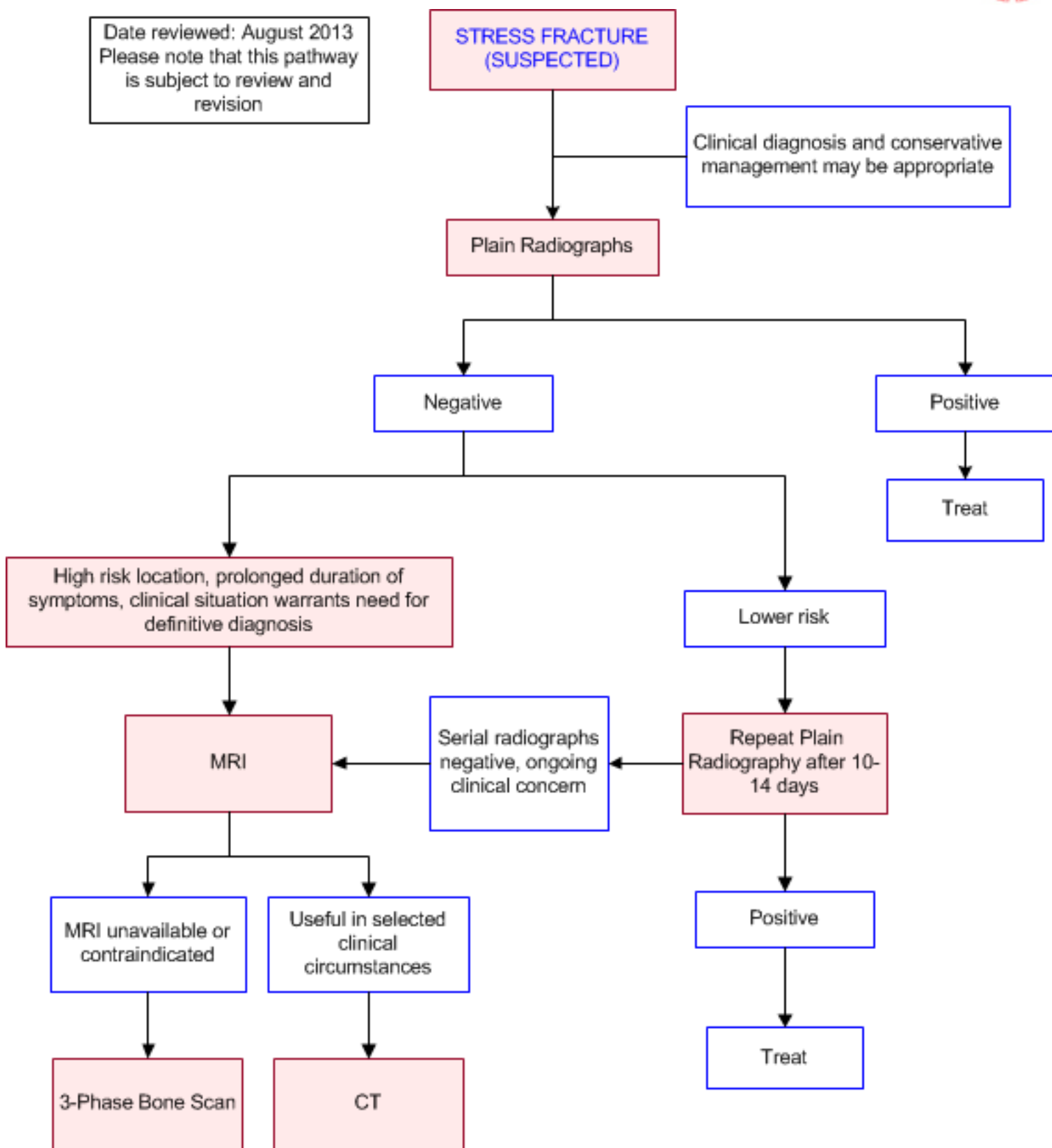


Image Gallery

Note: These images open in a new page

1a



Suspected Stress Fracture

Image 1a (Plain Radiography): Normal x-ray in 18 yo male with medial tibial pain.

1b

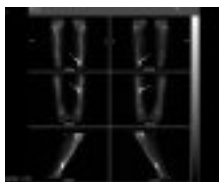


Image 1b (Bone Scan): Delayed phase of bone scan showing focal uptake in the posteromedial cortex typical of a stress fracture (arrow).

Teaching Points

- Plain radiographs are the initial imaging modality of choice, but are limited due to their inability to detect bony changes early in the development of a stress fracture
- Early radiographs are often normal. Consider repeat plain radiography at 10-14 days
- MRI is the most sensitive and specific investigation to diagnose a stress fracture when radiographs are normal or equivocal and can best evaluate for other differential diagnoses
- Scintigraphy has high sensitivity for stress fracture but poorer specificity, and is associated with ionising radiation exposure. It is an alternative when MRI is contraindicated or unavailable
- CT can be helpful as an alternative to MRI to demonstrate bony changes but is less sensitive

Plain Radiographs

- Initial imaging modality of choice for detection of suspected stress fractures [3](#)
- Highly specific (~96%) but poorly sensitive (~56%), limiting accuracy (~67%) [4](#)
 - When plain radiographs demonstrate changes consistent with stress fracture, such as linear cortical radiolucency or localised periosteal reaction [5-7](#), no further imaging is indicated [3](#)
 - Early radiographs are often normal or nonspecific. The lag time between manifestation of initial symptoms and detection of radiographic findings ranges from 1 week to several months [8](#)
 - Radiographs may be negative initially in 60-90% of patients and remain negative in 40-60% of stress fractures [5-7,9](#)
- If the plain radiographs are normal or non-diagnostic, options include
 - Treat the patient for a presumed fracture and repeat radiography in 2-3 weeks. The American College of Radiology Expert Panel suggest repeat radiography in 10-14 days [3](#)
- If definitive diagnosis is needed, further investigate with MRI (preferred over bone scan due to higher specificity and absence of ionising radiation)

Magnetic Resonance Imaging

- Comparable sensitivity and superior specificity to that of bone scan for detection of bone abnormalities [4,7,15-20](#)
- Aids in differentiating pathologic fractures from stress and insufficiency fractures [21](#) and superior soft tissue visualisation aids in differential diagnosis of pain
- Multiple classification systems for stress fractures have been developed to evaluate stress



fractures and a 'gold standard' is yet to be developed [22](#) Two four-stage grading scales using MRI have been published

- Arendt and Griffiths' scale has been used for the femur, tibia, fibular, navicular, calcaneus and forefoot and has prognostic implications regarding time of healing [23](#)
- Fredericson and colleagues' scale was developed using tibia data, and found presence of a fracture or cortical abnormality opposed to oedema alone predicted a longer symptomatic period in runners. [7](#) These findings were not replicated in a more heterogeneous study population [24](#)

Three-Phase Bone Scintigraphy

- A radiotracer (e.g. 99-Techneium-MDP) is injected into a vein after which a series of images are taken immediately (dynamic phase, demonstrating perfusion to a lesion), shortly after the injection (blood pool phase) and again 3-4 hours later (demonstrating relative bone turnover associated with a lesion)
- High sensitivity (~100%) for stress fractures. [4,12,25,26](#) 80% of all fractures show some scan abnormality 24 hours post-injury and 95% at 72 hours. [26](#) Classical findings include focally intense and fusiform cortical uptake
- The addition of SPECT to planar scintigraphy improves accuracy [27](#)
- Less specific than MRI. False positives can occur in osteoid osteoma, osteomyelitis, or metastatic disease [4,17](#)
- Not as useful in follow-up care as uptake can persist for months after clinical healing [28](#)
- Due to the radiation exposure and poorer specificity, the role of bone scintigraphy should be reserved to exclude a radiographically occult fracture in patients unable to undergo MRI or after an inconclusive MRI examination [19](#)

Computed Tomography

- Less sensitive than bone scintigraphy or MRI in the detection of stress fractures [17,29,30](#), but may better define an abnormality discovered with another modality [13](#) and have played a role in the diagnosis of longitudinal fractures [31](#)
- CT may occasionally depict osteopaenia, the earliest finding of a cortical stress injury, in symptomatic patients with normal MRI findings [17](#)
- May be useful in follow-up evaluation of healing in radiographically-occult fractures

Ultrasound

- While less accurate than MRI, use of ultrasound to evaluate stress fractures in the metatarsal bones has been evaluated with a reported 83% sensitivity and 76% specificity, compared to MRI as the gold standard [32](#)
- Performance has been poor in more common sites of stress fracture [33,34](#)
- Further studies are needed to determine the role of ultrasound in the evaluation of stress fracture

References

Date of literature search: April 2013

The search methodology is available on request. [Email](#)

References are graded from Level I to V according to the Oxford Centre for Evidence-Based Medicine, Levels of Evidence. [Download the document](#)

1. Boden BP, Osbahr DC. **High-risk stress fractures: evaluation and treatment.** J Am Acad Orthop Surg. 2000;8(6):344-53. (Review article)
2. Kaeding CC, Yu JR, Wright R, Amendola A, Spindler KP. **Management and return to play of stress fractures.** Clin J Sport Med. 2005;15(6):442-7. (Review article)
3. Expert Panel on Musculoskeletal Imaging; Daffner RH, Weissman BN, Appel M, Bancroft L, Bennett DL, et al. **ACR appropriateness criteria: stress (fatigue/insufficiency) fracture, including sacrum, excluding other vertebrae.** American College of Radiology; 2011 [cited 2013 April 1]. (Evidence based guideline) [View the reference](#)
4. Kiuru MJ, Pihlajamaki HK, Hietanen HJ, Ahovuo JA. **MR imaging, bone scintigraphy, and radiography in bone stress injuries of the pelvis and the lower extremity.** Acta Radiologica. 2002;43(2):207-12. (Level II/III evidence)
5. Kijowski R, Choi J, Mukharjee R, de Smet A. **Significance of radiographic abnormalities in patients with tibial stress injuries: correlation with magnetic resonance imaging.** Skeletal Radiol. 2007;36(7):633-40. (Level III evidence)
6. Giladi M, Ziv Y, Aharonson Z, Nili E, Danon YL. **Comparison between radiography, bone scan and ultrasound in the diagnosis of stress fractures.** Mil Med. 1984;149(8):459-61. (Review article)
7. Fredericson M, Bergman AG, Hoffman KL, Dillingham MS. **Tibial stress reaction in runners - correlation of clinical symptoms and scintigraphy with a new magnetic resonance imaging grading system.** Am J Sports Med. 1995;23(4):472-81. (Level III evidence)
8. Anderson MW, Greenspan A. **Stress fractures.** Radiology. 1996;199(1):1-12. (Review article)
9. Zwas ST, Elkanovitch R, Frank G. **Interpretation and classification of bone scintigraphic findings in stress fractures.** J Nucl Med. 1987;28(4):452-7. (Level III evidence)
10. Geslien GE, Thrall JH, Espinosa JL, Older RA. **Early detection of stress fractures using 99mTc-polyphosphate.** Radiology. 1976;121(3 Pt. 1):683-7. (Level III evidence)
11. Greaney RB, Gerber FH, Laughlin RL, Kmet JP, Metz CD, Kilcheski TS, et al. **Distribution and natural history of stress fractures in United States marine recruits.** Radiology. 1983;146(2):339-46. (Level II evidence)
12. Courtenay BG, Bowers DM. **Stress-fractures - clinical features and investigation.** Med J Aust. 1990;153(3):155-6. (Level IV evidence)
13. Matheson GO, Clement DB, McKenzie DC, Taunton JE, Lloydsmith DR, Macintyre JG. **Stress fractures in athletes - a study of 320 cases.** Am J Sports Med. 1987;15(1):46-58. (Level III evidence)
14. Prather JL, Nusynowitz ML, Snowdy HA, Hughes AD, McCartney WH, Bagg RJ. **Scintigraphic findings in stress fractures.** J Bone Joint Surg Am. 1977;59(7):869-74. (Level III/IV evidence)
15. Shin AY, Morin WD, Gorman JD, Jones SB, Lapinsky AS. **The superiority of magnetic resonance imaging in differentiating the cause of hip pain in endurance athletes.** Am J Sports Med. 1996;24(2):168-76. (Level III evidence)
16. Rizzo PF, Gould ES, Lyden JP, Asnis SE. **Diagnosis of occult fractures about the hip - magnetic-resonance imaging compared with bone-scanning.** J Bone Joint Surg Am. 1993;75A(3):395-401. (Level II evidence)
17. Gaeta M, Minutoli F, Scribano E, Ascenti G, Vinci S, Bruschetta D, et al. **CT and MR imaging findings in athletes with early tibial stress injuries: comparison with bone scintigraphy findings and emphasis on cortical abnormalities.** Radiology. 2005;235(2):553-61. (Level II evidence)
18. Deutsch AL, Mink JH, Waxman AD. **Occult fractures of the proximal femur - MR imaging.**



- Radiology. 1989;170(1):113-16. (Level III evidence)
19. Dobrindt O, Hoffmeyer B, Ruf J, Seidensticker M, Steffen IG, Zarva A, et al. **MRI versus bone scintigraphy. Evaluation for diagnosis and grading of stress injuries.** Nuklearmedizin. 2012;51(3):88-94. (Level II/III evidence)
 20. Ishibashi Y, Okamura Y, Otsuka H, Nishizawa K, Sasaki T, Toh S. **Comparison of scintigraphy and magnetic resonance imaging for stress injuries of bone.** Clin J Sports Med. 2002;12(2):79-84. (Level III evidence)
 21. Fayad L, Kawamoto S, Kamel I, Bluemke D, Eng J, Frassica F, et al. **Distinction of long bone stress fractures from pathologic fractures on cross-sectional imaging: how successful are we?** AJR Am J Roentgenol. 2005;185(4):915-24. (Level II/III evidence)
 22. Miller T, Kaeding CC, Flanigan D. **The classification systems of stress fractures: a systematic review.** Phys Sportsmed. 2011;39(1):93-100. (Level I/II evidence)
 23. Arendt EA, Griffiths HJ. **The use of MR imaging in the assessment and clinical management of stress reactions of bone in high-performance athletes.** Clin Sports Med. 1997;16(2):291-306. (Review article)
 24. Yao L, Johnson C, Gentili A, Lee JK, Seeger LL. **Stress injuries of bone: analysis of MR imaging staging criteria.** Acad Radiol. 1998;5(1):34-40. (Level III evidence)
 25. Shikare S, Samsi AB, Tilve GH. **Bone imaging in sports medicine.** J Postgrad Med. 1997;43(3):71-2. (Level IV evidence)
 26. Matin P. **Appearance of bone scans following fractures, including immediate and long-term studies.** J Nucl Med. 1979;20(12):1227-31. (Level II evidence)
 27. Bryant LR, Song WS, Banks KP, Bui-Mansfield LT, Bradley YC. **Comparison of planar scintigraphy alone and with SPECT for the initial evaluation of femoral neck stress fracture.** AJR Am J Roentgenol. 2008;191(4):1010-5. (Level III evidence)
 28. Diehl J, Best T, Kaeding C. **Classification and return-to-play considerations for stress fractures.** Clin Sports Med. 2006;25(1):17-28, vii. (Review article)
 29. Groves AM, Cheow HK, Balan KK, Housden BA, Bearcroft PWP, Dixon AK. **16-Detector multislice CT in the detection of stress fractures: a comparison with skeletal scintigraphy.** Clin Radiol. 2005;60(10):1100-5. (Level III evidence)
 30. Cabarrus MC, Ambekar A, Lu Y, Link TM. **MRI and CT of insufficiency fractures of the pelvis and the proximal femur.** AJR Am J Roentgenol. 2008;191(4):995-1001. (Level III evidence)
 31. Shearman CM, Brandser EA, Parman LM, El-Khoury GY, Saltzman CL, Pyevich MT, et al. **Longitudinal tibial stress fractures: a report of eight cases and review of the literature.** J Comput Assist Tomogr. 1998;22(2):265-9. (Review article)
 32. Banal F, Gandjbakhch F, Foltz V, Goldcher A, Etchepare F, Rozenberg S, et al. **Sensitivity and specificity of ultrasonography in early diagnosis of metatarsal bone stress fractures: a pilot study of 37 patients.** J Rheumatol. 2009;36(8):1715-9. (Level III evidence)
 33. Boam WD, Miser WF, Yuill SC, Delaplain CB, Gayle EL, MacDonald DC. **Comparison of ultrasound examination with bone scintiscan in the diagnosis of stress fractures..** J Am Board Fam Pract. 1996;9(6):414-7. (Level III evidence)
 34. Schneiders AG, Sullivan SJ, Hendrick PA, Hones BDGM, McMaster AR, Sugden BA, et al. **The ability of clinical tests to diagnose stress fractures: a systematic review and meta-analysis.** J Orthop Sports Phys Ther. 2012;42(9):760-71. (Level I evidence)

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