

# 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.

**Date reviewed: August 2013**

**Date of next review: 2017/2018**






**Published: August 2013**

## 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.

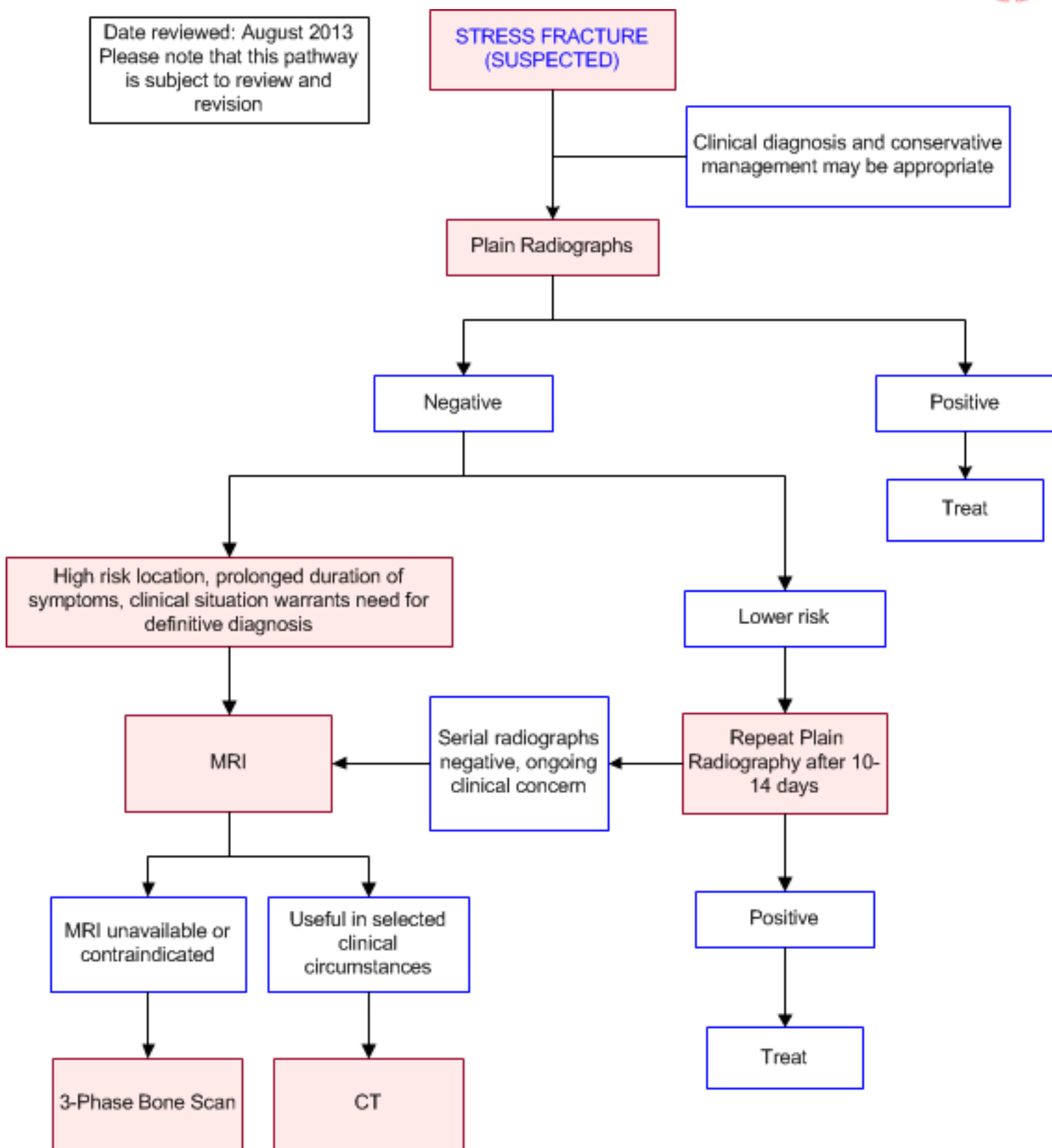
Clicking on the **PINK** text box will bring up the full text.

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*



### Suspected Stress Fracture

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

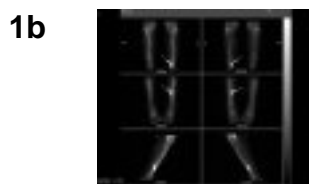


Image 1b (Bone Scan): Delayed phase of bone scan showing focal uptake in the posteromedial cortex typical of a stress fracture (arrow).

## 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)

## Information for Consumers

Information from this website	Information from the Royal Australian and New Zealand College of Radiologists' website
-------------------------------	--





<a href="#">Consent to Procedure or Treatment</a>	<a href="#">Computed Tomography (CT)</a>
<a href="#">Radiation Risks of X-rays and Scans</a>	<a href="#">Magnetic Resonance Imaging (MRI)</a>
<a href="#">Stress Fracture (Suspected)</a>	<a href="#">Plain Radiography/X-rays</a>
<a href="#">Bone Scan</a>	<a href="#">Radiation Risk of Medical Imaging During Pregnancy</a>
<a href="#">Computed Tomography (CT)</a>	<a href="#">Radiation Risk of Medical Imaging for Adults and Children</a>
<a href="#">Magnetic Resonance Imaging (MRI)</a>	<a href="#">Nuclear Medicine Bone Scan</a>
<a href="#">Plain Radiography (X-ray)</a>	<a href="#">Nuclear Medicine</a>
	<a href="#">SPECT-CT Scan</a>

## Copyright

© Copyright 2015, Department of Health Western Australia. All Rights Reserved. This web site and its content has been prepared by The Department of Health, Western Australia. The information contained on this web site is protected by copyright.

## Legal Notice

Please remember that this leaflet is intended as general information only. It is not definitive and The Department of Health, Western Australia can not accept any legal liability arising from its use. The information is kept as up to date and accurate as possible, but please be warned that it is always subject to change

## File Formats

Some documents for download on this website are in a Portable Document Format (PDF). To read these files you might need to download Adobe Acrobat Reader.

