

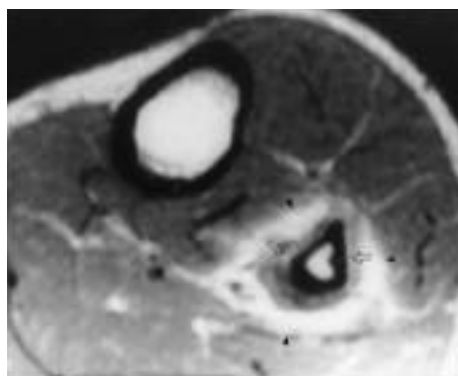
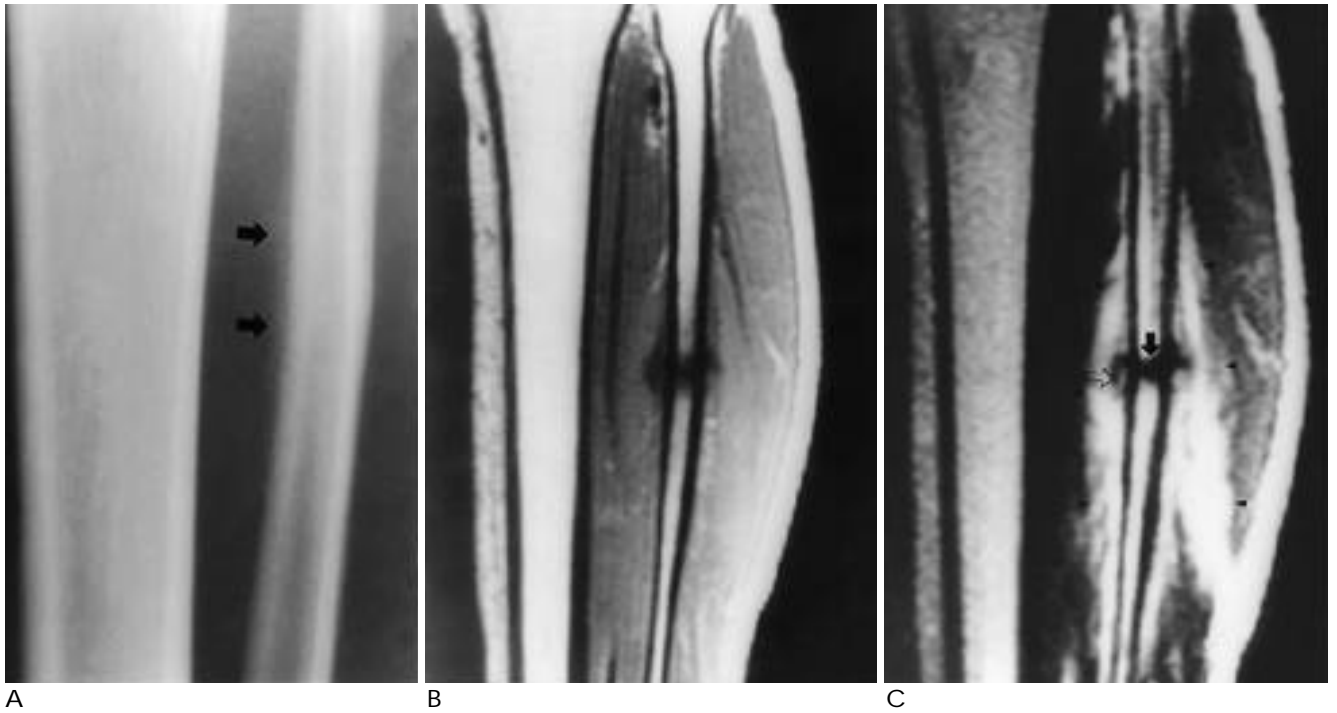
:
 :
 20 22 . 19-21 , ()
 , , , ,
 ,
 : 12 , 8 , 2 1 .
 10 , 9 , 2 ,
 1 6
 , 8 5 . 20
 (90%), 14 (64%),
 13 (59%) ,
 19 (86%), 18 (82%),
 :
 ,
 (stress fracture)
 가
 가 (fatigue fracture)
 (elastic resistance)
 가 (insufficiency fracture) 1996 4 1997 12
 2가 (1-3).
 , 가
 , 20 22 . 2
 가 ,
 가 (1-5). 19 21
 () 1 45
 (6), 15-40% 23 ,
 10 60 35 .
 (3, 7), 가 0.5 T (Gyros-
 can, Philips, Netherlands)
 T1 (TR/ TE = 375-500/21-25), T2
 (TR/TE = 1800/90) 3-10
 mm, 1.0-2.0 mm, 150-200 mm, 179 ×
 256 , 3-4 mm, 0.3-1.0
 mm, 300-375 mm, 179 × 256 .
 1998 11 10 1999 1 4

Gadolinium-DTPA (Magnevist, Schering, Germany)

10

(41%), 9 (35%), 2 (9%),
1 (5%)
5, 2, 6
2
20 (90%)
T1 T2
가 14 (64%)
7, 5, 2
13 (59%)
10, 3
7 (32%)
(Fig. 1).

12 (55%) 가 (6) (Fig. 2)
8 (35%), 2 1 5



D

Fig. 1. Fatigue fracture of the left fibula in a 19-year-old man.
A. Initial plain radiograph shows thin periosteal reaction in medial fibula(arrows).
B-D. MRI obtained 2 weeks after plain radiograph. T1 weighted oblique coronal image(B) shows bone marrow edema. T2 weighted oblique coronal image(C) shows intramedullary low signal intensity band (arrow) which is continuous with cortex as well as surrounding bone marrow edema in marrow space. High signal intensity in subperiosteal region(open arrow) and surrounding soft tissue edema (arrowheads) were noted. Gadolinium-enhanced T1 weighted axial image(D) demonstrates marked enhancement in bone marrow and surrounding soft tissue (arrowheads) and mild enhancement in subperiosteal region (open arrows), involving entire portion of fibula. Periosteal reaction involving same site is seen.

(Table 1)(Fig. 1).

19 (86%),

18 (82%),

가 가

Giladi(12)

(10 , 45%),

(16 , 73%),

(11 , 50%)

가

가

가

가

가

(1-3).

(1-3).

(1-5).

가

95%가

(6).

(trabecula)

가

(10),

가

가,

(1-3,

(5, 10, 11),

6).

15-40 %

(1-4).

(7).

Table 1. MRI Findings of Fatigue Fractures (N= 22)

MRI findings	No. of Cases	%
Bone marrow edema	20	90
Intramedullary low signal intensity band	14	64
Transverse	7	
Oblique	5	
Longitudinal	2	
Cortical fracture line	13	59
Oblique	10	
Transverse	3	
Periosteal reaction	22	100
Surrounding soft tissue edema	22	100

가

, 95 %

6-72

2-3

가 가

가

, 3

가

2

가

(12, 13).

(14),

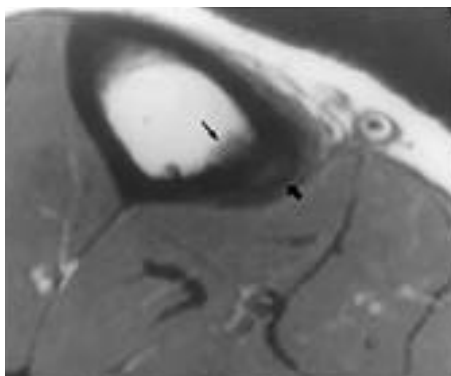
(8, 9). Tyrrell (9)

1)

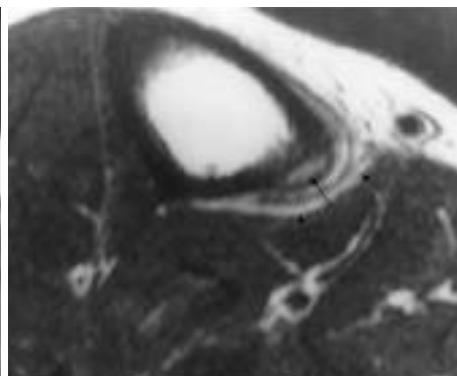
가

2)

T1



A



B

Fig. 2. Fatigue fracture of the right tibia in a 20-year-old man.

A. T1 weighted axial image shows focal bone marrow edema(long arrow) and periosteal reaction(short arrow) at posteromedial side of tibia

B. Gadolinium enhanced T1 weighted axial image demonstrates mild enhancement in bone marrow and subperiosteal region(arrow) and marked enhancement in surrounding soft tissue(arrowheads).

:
 , T2 STIR (18)
 3) T1
 , T2 STIR
 (sequence)
 Mink (15) 2가 (plane) (field of view)
 T1 T2 가
 (linear type) 가
 T1 , T2 (9). ,
 (amorphous type) (13 , 59%) (7 , 32%)
 ,
 Stafford (16) (21).
 T1 T2 Fredericson (22)
 , Tyrrell (9)
 Meyers (17)
 . Lee (8)
 3
 가 , Meyers (17) STIR T2
 T1 가
 (9). , 가
 20 (90%) , 가
 (14) 가
 ,
 (4). (3, 23).
 Lee (8) Tyrrell (9) T1 가
 가 . Meyers (17)
 가
 가 14
 (64%)
 , Devas(18) T1 , T2 가
 10%
 , Umans (19) T1
 (shaft) , T2
 가 14
 2
 Tyrrell (9) 7 (24).
 , (18) 14 10 (71%)
 14 (64%) 가 (25).
 Tyrrell (9) 7 4 (57%) , (18) 14
 12 (86%)
 22 13 (59%)

가

1. Anderson MW, Greenspan A. Stress fractures. *Radiology* 1996;199:1-12
2. Umans H, Pavlov H. Stress fracture of the lower extremities. *Semin Roentgenol* 1994;29: 176-193
3. Daffner RH, Pavlov H. Stress fractures : current concepts. *AJR* 1992;159:245-252
4. Matheson GO, Clement DB, McKenzie DC, Taunton JE, Lloyd-Smith DR, Macintyre JG. Stress fracture in athletes : a study of 320 cases. *Am J Sports Med* 1987;15:46-57
5. Brukner P, Bennel K. Stress fracture in female athletes. *Sports Med* 1997;24: 419-429
6. Savoca CJ. Stress fracture : a classification of the earliest radiographic signs. *Radiology* 1971;100:519-524
7. Greaney RB, Gerber FH, Laughlin RL, et al. Distribution and natural history of stress fracture in U.S. Marine recruits. *Radiology* 1983;146:339-346
8. Lee JK, Yao L. Stress fracture : MR imaging. *Radiology* 1988;169:217-220
9. Tyrrell PNM, Davies AM. Magnetic resonance imaging appearances of fatigue fracture of the long bones of the lower limb. *Br J Radiol* 1994;67:332-338
10. Wilson ES, Katz FN. Stress fracture : an analysis of 250 consecutive cases. *Radiology* 1969;92:481-486
11. Zwas ST, Elkanovitch R, Frank G. Interpretation and classification of bone scintigraphic findings in stress fracture. *J Nucl Med* 1987; 28:452-457
12. Giladi M, Ahronson Z, Stein M, Danon YL, Milgrom C. Unusual distribution and onset of stress fractures in soldiers. *Clin Orthop Rel Res* 1985;192:142-146
13. Matin P. The appearance of bone scans following fractures, including immediate and long term studies. *J Nucl Med* 1979;20:1227-1231
14. Vogler JB, Murphy WA. Bone marrow imaging. *Radiology* 1988;168:679-693
15. Mink JH, Deutsch AL. Occult cartilage and bone injuries of the knee: detection, classification, and assessment with MR imaging. *Radiology* 1989;170:823-829
16. Stafford SA, Rosenthal DI, Gebhardt MC, Brady TJ, Scott JA. MRI in stress fracture. *AJR* 1986;147:553-556
17. Meyers SP, Wiener SN. Magnetic resonance features of fractures using the short tau inversion recovery(STIR) sequence : correlation with radiographic findings. *Skeletal Radiol* 1991;20:499-507
18. Devas MB. Longitudinal stress fracture : another variety seen in long bones. *J Bone Joint Surg (Br)* 1960;42:508-514
19. Umans HR, Kaye JJ. Longitudinal stress fracture of the tibia : diagnosis by magnetic resonance imaging. *Skeletal Radiol* 1996;25:319-324
20. , , .
1998
1998:52-53
21. Allen GJ. Longitudinal stress fractures of the tibia : diagnosis with CT. *Radiology* 1998;167:799-801
22. 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;23:472-481
23. Deely DM, Schweitzer ME. MR imaging of bone marrow disease. *Radiol Clin North Am* 1997;35:193-212
24. Bloem JL. Transient osteoporosis of the hip : MR imaging. *Radiology* 1998;167:753-755
25. Deutsch AL, Mink JH, Waxman AD. Occult fractures of the proximal femur: MR imaging. *Radiology* 1989;170:113-116

MR Imaging Findings of Fatigue Fractures of Lower Extremity in Young Soldiers¹

Jong Hyun Mo, M.D., Jin Kyoong Park, M.D.², Sung Hee Moon, M.D.,
Young Bok Kim, M.D., Yang Hee Park, M.D.

¹Department of Diagnostic Radiology, National Police Hospital

²Department of Diagnostic Radiology, Chonnam National Medical School

Purpose: To evaluate the MR imaging findings of fatigue fractures of the lower extremity in young soldiers.

Materials and Methods: In 22 cases of fatigue fractures of the lower extremity in young soldiers proven by clinical findings and radiological follow up, the MRI findings were retrospectively evaluated. All patients were male and aged between 19 and 21 years. As seen on MRI, the bone marrow edema, intramedullary low signal intensity band, cortical fracture line, periosteal reaction, surrounding soft tissue edema, and enhancement pattern were analyzed and the site of involvement was determined in the axial plane.

Results: The locations of fatigue fractures of the lower extremity were the tibia (n= 12), fibula (n= 8), femur (n= 1) and second metatarsus (n= 1). All occurred in diaphyses: the junction of the proximal and middle (n= 10), middle (n= 9), proximal (n= 2), and distal shaft (n= 1). The sites of involvement were the posteromedial (n= 6) and medial side (n= 6) of the tibia, and the entire portion of the fibula (n= 5) in the axial plane. MRI findings were bone marrow edema in 20 cases, intramedullary low signal intensity band in 14 (which were continuous with the cortex or cortical fracture line), cortical fracture line in 13, and periosteal reaction and surrounding soft tissue edema in all. On gadolinium-enhanced images, enhancement was seen in the bone marrow in 19 cases, in the subperiosteal region in 18, and in the surrounding soft tissue in 22.

Conclusion: In fatigue fractures of the lower extremity in young soldiers, the main locations were the tibia and fibula, and characteristic MR imaging findings were intramedullary low signal intensity bands, which were continuous with the cortex or cortical fracture line and often accompanied by bone marrow edema, periosteal reaction, and surrounding soft tissue edema.

Index words: Fracture, stress
Fracture, MR
Tibia, fractures

Address reprint requests to : Jong Hyun Mo, M.D., Department of Radiology, National Police Hospital
58 Karac bon-dong, Songpa-ku, Seoul, 138-169, Korea.
Tel. 82-2-3400-1318 Fax. 82-2-408-4547