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Clinical Quiz

# Fatigue Fracture of the Femoral Neck

**Christos Koutserimpas[1,2], Nikolaos-Achilleas Arkoudis[3], Efstathios Chronopoulos[4], Konstantinos Dretakis[5], Maria Piagkou[1], Kalliopi Alpantaki[6]**

[1]Department of Anatomy, School of Medicine, National and Kapodistrian University of Athens, Greece;
[2]Department of Orthopaedics and Traumatology, "251" Hellenic Air Force General Hospital of Athens, Greece;
[3]Research Unit of Radiology and Medical Imaging, 2nd Department of Radiology, Medical School, National and Kapodistrian University of Athens, Athens, Greece;
[4]Laboratory for Research of the Musculoskeletal System, School of Medicine, National and Kapodistrian University of Athens, Greece;
[5]2nd Department of Orthopaedics, "Hygeia" General Hospital of Athens, Greece;
[6]Department of Orthopaedics and Traumatology, "Venizeleion" General Hospital of Heraklion, Crete, Greece

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## Case

A 52-year-old female presented to the emergency department due to persistent left groin pain and an inability to bear full weight on the left lower limb. The patient described that this vague pain in the left groin area began about 3 months ago. Initially, she could walk, bearing full weight, but with pain, which exacerbated with movements of the hip joint (mainly external rotation and abduction). The patient was a heavy smoker for 22 years, while her remaining medical history was unremarkable. She also stated that she was performing field labor as a farmer for a couple of months prior to the symptoms' onset. She did not mention any traumatic events.

Upon presentation, the patient was hemodynamically stable (blood pressure= 135/85 mmHg, heart rate=83 beats/min, respiratory rate=12 breaths/min) and afebrile (36.6°C). Clinical examination revealed pain in the left groin and thigh, while she could not perform hip flexion. Passive flexion of the hip was extremely painful. The knee joint had a painless full range of motion. No neurovascular deficit was evident, while the ankle-brachial pressure index was 1.1 [normal range (nr):1-1.2].

Initial X-rays displayed a radiolucent line completely traversing the femoral neck. These findings were consistent with a complete, nondisplaced subcapital fracture, classified as Garden II (Figure 1A). Laboratory examination, including calcium= 8.8 mg/dL (nr=8.1-10.4 mg/dL), phosphate=4.2 mg/dL (nr=2.5-5 mg/dL), 25-hydroxyvitamin D= 22.5 ng/ml (nr=20-40 ng/ml), alkaline phosphatase (ALP)=41 U/L (nr= 40-150 U/L) and parathormone= 46.2 pg/ml (nr=18.5-88 pg/ml), was within normal limits.

Moreover, a computer tomography (CT) scan showed the fracture line crossing the neck of the left femur, while the sclerotic appearance of the bone surrounding the fracture line is evidence of the fracture's chronicity (Figure 1B). Magnetic resonance imaging (MRI) performed further verified these findings by displaying the fracture line with adjacent sclerosis and the absence of bone marrow oedema. (Figure 1C, D). Dual energy x-ray absorptiometry (DEXA) revealed T-score= -0.8 (proximal femur) and -0.9 (lumbar spine).

The patient was diagnosed with a femoral neck fatigue fracture (FNFF). She was treated operatively with cannulated screw fixation. She was also commenced on Vit-D supplementation (25,000 IU per 2 weeks) and was advised to visit the smoking cessation department. No-weight bearing was followed for 4 weeks, and protected weight bearing with gradual increase in activities for another 6 weeks. The patient returned to her daily lifestyle 4 months after the surgery.

## Commentary

Fatigue fractures are observed in healthy bones with repetitive loading over a long period of time[1]. In particular, continuous microscopic fractures exceed osteoblastic activity, resulting in a fatigue fracture. These fractures have been frequently reported in athletes and military recruits due to overuse. The development of these injuries represents a

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*Corresponding author: C. Koutserimpas, MD, PhD, Kanellopoulou Av 3, PC 11525, Athens, Greece*
*E-mail: chrisku91@hotmail.com*

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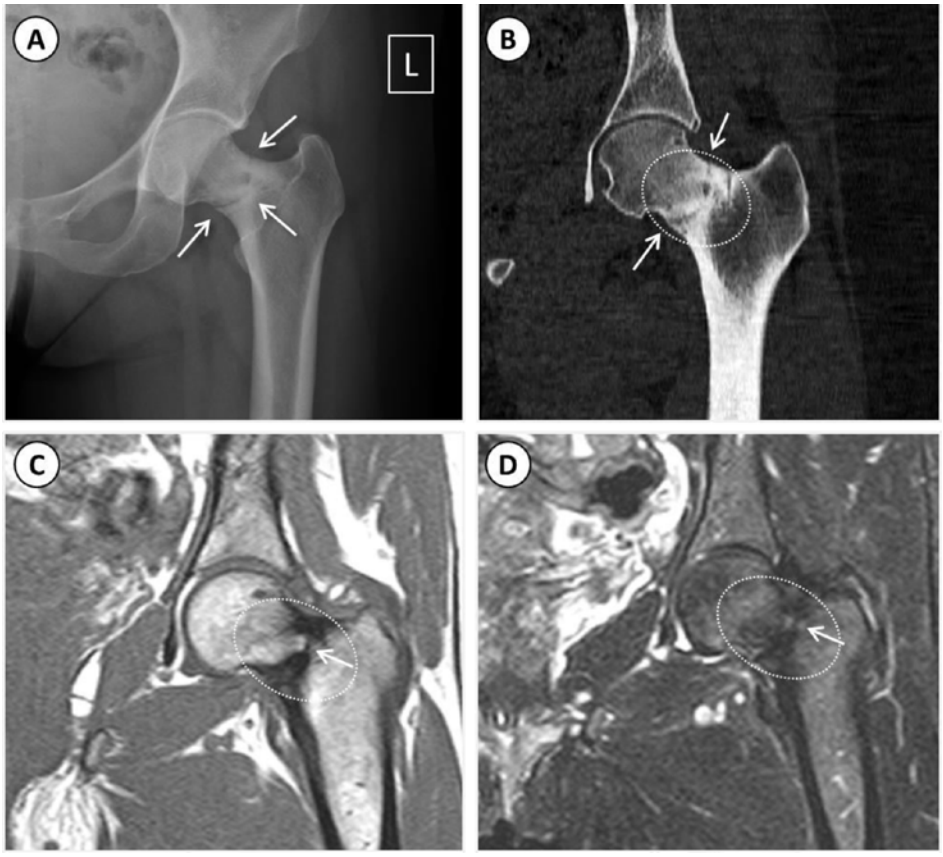


**Figure 1.** (A) Anteroposterior view of the initially obtained X-ray of the left hip evident-ly displays a radiolucent line (arrows) completely traversing the femoral neck. (B) Cor-onal reconstruction of a computer tomography (CT) scan also demonstrates the fracture line crossing the neck of the left femur in its entirety (complete fracture) (arrows). Also note the sclerotic appearance of the bone surrounding the fracture line as evidence of its chronicity (dashed oval). The findings were consistent with a complete, nondisplaced subcapital fracture (Garden type II). (C) Coronal T1-weighted non-fat-saturated MRI images and (D) coronal T2-weighted fat-saturated MRI images display a low signal in-tensity line in the left femoral neck, indicative of a fracture (arrow). Diffuse low-signal intensity changes surrounding the fracture are suggestive of adjacent sclerosis (dashed oval). The absence of increased signal intensity changes (in the T2-weighted fat-saturated MRI images) in the bone marrow surrounding the fracture indicates that this fracture has not occurred recently.

complex process involving various factors, often stemming from repeated submaximal stresses[1,2]. Additionally, intrinsic factors like hormonal imbalances may contribute, particularly in females. It is of note that the anatomical site of the fatigue fracture has been documented to be activity-dependent. Hence, fatigue fractures of the metatarsals and the anterior shaft of the tibia have been associated with dancers, while those of the proximal medial posterior tibia, the navicular of the foot, and the femoral neck have been associated with long-distance runners[2,3].

The typical scenario involves a patient experiencing gradual pain following a sudden increase in exercise duration or intensity. The primary method for diagnosis is clinical evaluation, but various imaging techniques, including plain radiography, scintigraphy, computed tomography, and magnetic resonance imaging, may provide valuable information and confirm the diagnosis[3].

A FNFF is caused by repetitive loading of the femoral neck that leads to either compression side (inferior-medial neck) or tension side (superior-lateral neck) stress frac-tures[1,3]. Regarding demographics and risk factors, FNFFs may be observed more in Caucasian females. High training volume and intensity, as well as low Body Mass Index (BMI), decreased bone mineral density, and smoking, have been described as risk factors. Regarding anatomical risk factors, the coxa vara, femoroacetabular impingement, and abnormal running gait pattern have also been recognized[2,4,5]. It should also be noted, in terms of applied anatomy, that the hip extensor muscles induce the highest tensile strain in proximal-posterior neck cortex and compressive strain in the anterior neck, the hip flexors the highest compressive strain in the proximal-posterior neck cortex and tensile strain in the anterior neck,

and the hip abductors the highest compressive strain in the distal and superolateral femoral neck. Moreover, regarding biomechanics, 3-5 times the body weight is applied at the femoral neck during running, while these forces reach 8.4 times the body weight during running[3,4].

There are mainly two types of FNFF, the compression-sided fractures, in which compressive forces occur primarily along the inferior femoral neck near the calcar region, and tension-sided fractures, in which bending forces along the superolateral neck are stabilized by abductor forces and are considered more unstable[1,3].

Regarding the diagnostic approach, the history of overuse activities is of paramount importance. There is usually an insidious onset of pain located in the groin region and/or the thigh, which increases with weight bearing. X-rays may be helpful for diagnosis, but it should be noted that in most cases, they are normal during the first 6 weeks[2-5]. MRI has become the modality of choice, revealing periosteal or bone marrow edema on STIR or fat-suppressed T2-weighted images in the acute phase and/or a line of decreased signal intensity transversing within it. Bone scintigraphy may also be used in cases where MRI is contraindicated, since it has been largely replaced by MRI[3-5]. Nonoperative treatment is indicated for compression-sided fractures with <50% femoral neck width. Cannulated screw fixation is indicated for tension-sided stress fractures or compression-sided fractures with >50% width or hip effusion. The main complications are avascular necrosis, delayed union, non-union, and varus malunion[1,3].

Increased awareness of this clinical entity is of utmost importance, since due to the lack of a traumatic event, these injuries may be misdiagnosed. A thorough medical history, clinical examination, and appropriate imaging will lead to a diagnosis, especially in the early stages where the fracture is not apparent.

*Consent to Publish*

*Written consent for publication was obtained from the patient.*

*Authors' Contributions*

*All authors were involved in caring for the patient. NAA and CK wrote the original draft. NAA, KA, KD, MP extracted and prepared the figures. EC, KD, KA, MP and CK assisted with literature search and conceptualization of the manuscript. All authors reviewed and approved the final manuscript.*

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## Questions

1. In a marathon runner with groin pain and antalgic gait, the initial antero-posterior and lateral X-ray views are negative for pelvic or hip fracture; the most appropriate imaging method for diagnosis is:

A. Computer Tomography scan.
B. Magnetic resonance imaging.
C. Repeat X-rays including the frog leg lateral view.
D. None of the above.

*Critique*

X-ray views may not reveal a fatigue fracture, especially during the first 6 weeks. Mag-netic resonance imaging has been documented as the modality of choice, encompassing the higher sensitivity for early detection of fatigue fractures. The correct answer is B.

2. Which of the following fatigue fractures of the femoral neck may be treated con-servatively:

A. A displaced fatigue femoral neck fracture in a 32-year-old male runner.
B. A tension sided fatigue fracture of the femoral neck in a 41-year-old female jogger.
C. An incomplete (<50% neck width) compression-sided fatigue fracture of the femoral neck in a 20-year-old male military recruit.
D. None of the above.

*Critique*

Very large forces are applied in the hip joint and the femoral neck during activities. Complete fractures (Garden III or IV) require operative treatment and have high potential for avascular necrosis. Tension sided fatigue fractures of the femoral neck also require surgical intervention, tensile forces

and the relative avascularity at the site of a stress-induced fracture often lead to poor healing. Compression-sided incomplete fractures of the femoral neck may be treated non-operatively due to higher healing potential.
The correct answer is C.

**3.** Which of the following is not a risk factor for a fatigue fracture of the femoral neck:
A. Low body mass index.
B. Female gender.
C. Caucasian race.
D. None of the above.

*Critique*

The risk factors for fatigue fractures of the femoral neck may be activity related (military recruits, long distance runners), medical (Low body mass index, smoking) and anatomical (coxa vara, femoroacetabular impingement). There are also demographic risk factors, since these fractures are more closely associated with the female gender.
The correct answer is D.