

Clinical Quiz

Avascular Necrosis of the Femoral Head Following Posterior Hip Dislocation in an Adolescent

Symeon Naoum¹, Christos Koutserimpas², Amr ElKhouly¹, Neville C. Davies¹, Evdokia Billis^{2,3}, Maria Piagkou⁴, Charalampos Matzaroglou², Efstathios Chronopoulos⁵

¹Department of Trauma and Orthopaedics, Royal Berkshire Hospital, Reading, UK;

²School of Health Rehabilitation Sciences, University of Patras, Greece;

³Laboratory of Clinical Physiotherapy and Research, Department of Physiotherapy, University of Patras, Rio, Greece;

⁴Department of Anatomy, School of Medicine, Faculty of Health Sciences, National and Kapodistrian University of Athens, Greece;

⁵Laboratory for Research of the Musculoskeletal System, School of Medicine, National and Kapodistrian University of Athens, Greece

Keywords: Avascular Necrosis, Femoral Head, Hip, Hip Dislocation, Traumatic Necrosis

Case

A 15-year-old male presented eight months after a traumatic posterior hip dislocation sustained during a football match, with progressively worsening right hip pain and stiffness. The dislocation had been reduced within approximately 2 hours of injury, with post-reduction radiographs confirming concentric reduction and a minimally displaced posterior wall fracture, without intra-articular fragments; neurological examination was normal. He underwent protected weight-bearing and physiotherapy with gradual improvement, allowing return to low-intensity, non-contact football training. After an initial period of clinical improvement, insidious activity-related groin pain recurred approximately six months after injury, without additional trauma. He demonstrated a mildly antalgic gait without limb discrepancy or deformity. Examination revealed groin/anterior joint line tenderness and pain-limited hip motion (flexion 80°, internal rotation 10°, abduction 30°), with a 5° fixed flexion deformity. FABER and FADIR reproduced anterior groin pain, while log-roll was painful but stable. Neurovascular examination was normal.

Christos Koutserimpas is a consultant for Smith and Nephew and has received funding from the 'MEDIKUS' program for research and innovation by the University of Patras. The remaining authors have nothing to declare.

Corresponding author: C. Koutserimpas, MD, PhD, School of Health Rehabilitation Sciences, University of Patras, Greece
E-mail: koutserimpas@upatras.gr

Edited by: G. Lyritis

Accepted 2 February 2026

Radiographs showed preserved hip congruence with subtle superolateral femoral head contour irregularity and no definite collapse (Figure 1). MRI demonstrated a well-defined superolateral necrotic focus with T1 hypointensity, T2/STIR marrow edema, and a subchondral low-signal rim with minimal surface flattening, without a displaced subchondral fracture or loss of femoral head sphericity (Figure 2). These findings were interpreted as incipient (pre-collapse) structural compromise, indicating increased collapse risk rather than established collapse. The acetabulum and physis were intact, with no intra-articular fragments. Overall, imaging was consistent with traumatic avascular necrosis (AVN) of the femoral head, ARCO stage II (Steinberg IIb). The Kerboul angle was 157°.

Following multidisciplinary review, initial conservative management was decided. Although joint-preserving options, such as core decompression were considered, the absence of established collapse, limited necrotic involvement, and preserved femoral head morphology favored non-operative treatment. The patient commenced physiotherapy with gradual return to full weight-bearing.

Follow-up imaging at 10 months post-injury showed increased marginal sclerosis without radiographic progression, consistent with early reparative change. At the most recent review (12 months post-injury and 4 months after AVN diagnosis), the patient reports mild activity-related groin discomfort, near-full pain-free range of motion, and remains fully ambulatory, with stable femoral head morphology.

Commentary

AVN of the femoral head is a progressive condition resulting from disruption of the subchondral blood supply,





Figure 1. **A:** Anteroposterior pelvis radiograph obtained eight months after injury demonstrates preserved joint congruence with subtle sclerosis and contour irregularity of the superolateral femoral head (white arrows), without a visible crescent sign or definite collapse. **B:** Frog-leg lateral view confirms mild surface irregularity without loss of femoral head sphericity. **C:** Follow-up anteroposterior pelvis radiograph at ten months shows progressive marginal sclerosis and minimal surface flattening, consistent with reparative change rather than established collapse.



Figure 2. **A:** Coronal T2-weighted fat-saturated MRI of the right hip demonstrating avascular necrosis of the superolateral femoral head, characterized by a subchondral low-signal rim and surrounding marrow edema. Mild contour irregularity and minimal flattening of the articular surface are present, without a displaced subchondral fracture or established collapse, representing incipient structural failure. Associated synovitis and capsular thickening are also seen. **B:** Coronal T1-weighted MRI showing loss of normal fatty marrow signal within the necrotic region of the right femoral head, corresponding to the area of AVN. Subtle degenerative changes of the lateral acetabular labrum are also evident.

leading to ischemia, bone necrosis, and potential structural collapse¹. The femoral head is particularly vulnerable due to its reliance on the terminal retinacular branches of the medial femoral circumflex artery, which offer limited collateral circulation. Once perfusion is compromised, rapid osteocyte necrosis ensues, triggering bone resorption and mechanical weakening that may culminate in articular collapse and secondary osteoarthritis^{1,2}.

The etiological spectrum of femoral head AVN is broadly divided into traumatic and non-traumatic causes². Traumatic avascular necrosis most commonly follows femoral neck fractures or hip dislocations, in which injury to the posterior superior retinacular branches of the medial femoral circumflex artery; the principal blood supply to the femoral head from adolescence through adulthood, compromises femoral head perfusion. In this setting, time to reduction represents the most important modifiable prognostic factor, with delayed reduction markedly increasing the risk of AVN. In contrast, non-traumatic AVN predominates in adults and is most often associated with corticosteroid exposure or alcohol misuse, factors rarely relevant in otherwise healthy adolescents. In the pediatric population, the principal diagnostic consideration is Legg–Calvé–Perthes disease, which differs from traumatic AVN in its idiopathic etiology, more gradual onset, characteristic age range, and typically prolonged remodeling course, whereas traumatic AVN follows a clear vascular insult and may demonstrate a more abrupt radiological evolution.

The clinical presentation of AVN is stage-dependent. Early disease often causes nonspecific, activity-related groin or thigh pain, while progression leads to restricted motion, limp, and mechanical symptoms once subchondral collapse occurs. Because early manifestations are subtle, diagnosis requires a high index of suspicion, particularly in at-risk patients³.

Imaging is fundamental for diagnosis, staging, and treatment planning¹. Radiographs are often normal in early disease but may later show sclerosis, cystic change, or the characteristic crescent sign of a subchondral fracture. MRI remains the gold standard for early detection, demonstrating marrow edema and the double-line sign on T2-weighted sequences, which reflect reactive granulation tissue bordered by sclerosis. CT is less sensitive in early stages but offers superior delineation of subchondral fractures, articular surface integrity, and collapse morphology when surgical planning is required. Bone scintigraphy, historically used, demonstrates variable uptake patterns but lacks the specificity of MRI³.

The differential diagnosis of hip pain resembling AVN is age-dependent. In adolescents, the main consideration is Legg–Calvé–Perthes disease, which differs in etiology and typically follows a more gradual course, whereas degenerative disease and subchondral insufficiency fractures are uncommon and benign bone tumors represent rare alternative¹.

Multiple classification systems guide staging and management. The Ficat–Arlet classification ranges from

early symptomatic disease with normal radiographs to advanced femoral head collapse and secondary arthritis³. The Steinberg and ARCO systems incorporate MRI findings to improve prognostic accuracy by accounting for lesion size and location, with Stage II corresponding to pre-collapse disease (radiographic changes without subchondral fracture) and Stage III indicating early collapse with subchondral structural failure but preserved joint space. The Kerboul method, based on the combined necrotic arc on coronal and sagittal MRI, further refines risk stratification, with larger angles strongly associated with femoral head collapse. In the present case, a combined Kerboul angle of 157° falls below commonly reported high-risk thresholds (≈200°), supporting classification as a limited lesion with a comparatively lower risk of structural collapse and aligning with the decision for initial conservative management.

These parameters guide selection of joint-preserving strategies, such as core decompression or biologic augmentation, typically reserved for pre-collapse disease with a high risk of progression. In adolescents, limited lesions involving a smaller proportion of the weight-bearing dome are often managed conservatively, whereas more extensive involvement or early structural failure may warrant surgery. In the present case, despite the traumatic etiology, the limited necrotic extent, preserved femoral head sphericity, and absence of established collapse supported an initial non-operative approach.

Management of AVN is stage dependent and aims to preserve the native joint when feasible. Core decompression remains the principal surgical option in pre-collapse disease, with or without graft or biologic augmentation, while joint-preserving options diminish once collapse or secondary osteoarthritis develops, making total hip arthroplasty inevitable; particularly challenging in adolescents because of implant longevity. In our patient, increased marginal sclerosis and absence of a discrete subchondral fracture line on follow-up imaging were interpreted as reparative remodeling rather than true reversal of necrosis. This response likely reflects the patient's young age, open physes, and ongoing skeletal growth, which confer greater regenerative capacity than in adults. Overall, outcomes depend not only on the presence of necrosis but also on lesion extent, topography, femoral head structural integrity, and patient age⁴. Some studies in pediatric and adolescent populations suggest that early-stage traumatic AVN can demonstrate partial reparative remodeling without progression to collapse, particularly when lesion size is limited and structural integrity of the femoral head is preserved, e.g., for ARCO stage I–III⁵.

In summary, AVN of the femoral head is a multifactorial condition with a predictable progression when untreated. Even minor vascular compromise can precipitate irreversible structural damage. Early recognition through MRI, accurate staging using validated classification systems, and prompt implementation of joint-preserving measures remain central to optimizing outcomes. Despite advances in biologic and surgical strategies, continued surveillance of at-risk

individuals and early diagnosis are essential components of effective management.

Acknowledgments

The authors acknowledge the use of an artificial intelligence-based language assistance tool (ChatGPT, OpenAI) for English language editing and stylistic refinement of the manuscript. The tool was used solely to improve clarity and readability; all clinical content, interpretation, and conclusions were generated by the authors, who take full responsibility for the manuscript.

Consent to publish

Written consent for publication was obtained from the patient.

References

- Konarski W, Poboży T, Śliwczyński A, Kotela I, Krakowiak J, Hordowicz M, Kotela A. Avascular Necrosis of Femoral Head-Overview and Current State of the Art. *Int J Environ Res Public Health*. 2022 Jun 15;19(12):7348.
- Milenkovic S, Mitkovic M, Mitkovic M. Avascular necrosis of the femoral head after traumatic posterior hip dislocation with and without acetabular fracture. *Eur J Trauma Emerg Surg*. 2022 Feb;48(1):613-619.
- Braun ME, Fernandez Fernandez F, Riha L, Schmal H, Schmittenebecher P, Schneidmueller D, Strüwind C, Schwerk P, Reineke S, Traub F, Ihle C, Lieber J, Wack C, Rütter H, Baumann F, Marzi I, Busse LC, Tüshaus L, Adrian M, Bergmann F, Graf A, Kaiser MM, Loose O. Traumatic hip dislocations in children and adolescents: diagnostic challenges and the significance of MRI imaging-a multi-center study. *Eur J Trauma Emerg Surg*. 2025 May 6;51(1):194.
- Kim HKW, Morris WZ. Pediatric femoral head osteonecrosis secondary to trauma, sickle cell disease, and corticosteroid therapy. *J Pediatr Orthop Soc N Am*. 2021;3(2):285.
- Lou Y, Wu J, Zhong Y, Tong P, Du W. Etiology, pathology, and treatment of osteonecrosis of the femoral head in adolescents: A comprehensive review. *Medicine (Baltimore)*. 2024;103(30):e39102.

Questions

- What is the single most important modifiable prognostic factor for preventing AVN after traumatic hip dislocation?
 - Patient age
 - Time to reduction
 - Presence of acetabular fracture
 - Mechanism of injury

Critique

Time to reduction is the most important modifiable determinant of femoral head viability, with AVN risk increasing markedly beyond 6 hours. In this patient, prompt concentric reduction likely mitigated vascular insult. Age and mechanism are non-modifiable, while associated fractures influence severity but are less predictive of AVN than ischemia duration.

Correct Answer: B

- Which artery provides the principal blood supply to the femoral head in adolescents?
 - Obturator artery
 - Medial femoral circumflex artery
 - Lateral femoral circumflex artery
 - Inferior gluteal artery

Critique

The medial femoral circumflex artery, via its posterior retinacular branches, supplies most of the femoral head in adolescents. These vessels are particularly vulnerable in posterior dislocations, as in this case. The obturator artery contributes via the ligamentum teres but is insufficient alone, while lateral femoral circumflex and inferior gluteal arteries play minor roles.

Correct Answer: B

- What is the earliest and most sensitive imaging modality for detecting AVN of the femoral head?
 - X-ray
 - CT scan
 - MRI
 - Bone scintigraphy

Critique

MRI is the most sensitive modality for early AVN, detecting ischemia, marrow edema, and subchondral changes before radiographic collapse. X-rays and CT lack sensitivity early, while bone scintigraphy is less specific and largely supplanted by MRI.

Correct Answer: C

4. Which of the following factors most strongly correlates with the risk of femoral head collapse in traumatic AVN?
- A. Size and location of the necrotic lesion
 - B. Patient activity level
 - C. Use of physiotherapy and rehabilitation protocols
 - D. Presence of hip effusion on MRI

Critique

The extent and topography of the necrotic lesion are the strongest predictors of femoral head collapse. Lesions involving the superolateral weight-bearing dome or with large Kerboul angles ($>200^\circ$) carry the highest risk. Patient activity level may influence symptoms but does not determine structural failure, while activity modification and physiotherapy do not alter disease progression. Hip effusion on MRI is nonspecific and does not predict collapse. Correct Answer: A