Traumatic and Iatrogenic Osteonecrosis

Current Concepts

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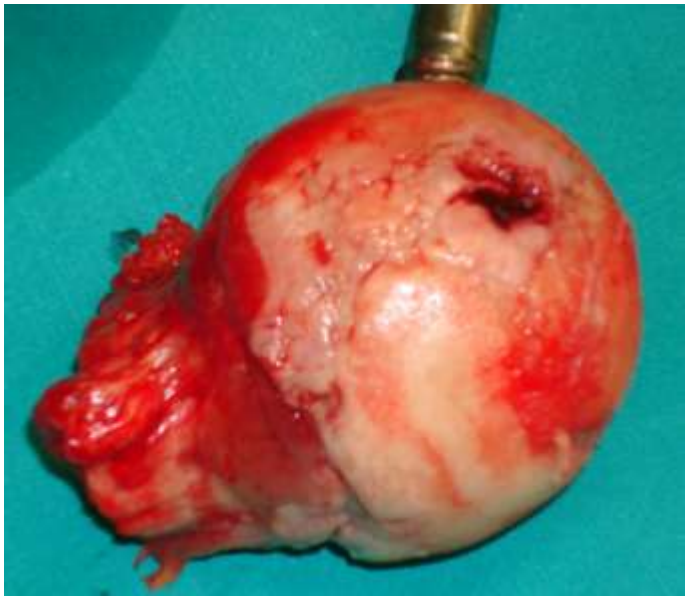
Definition

AVN = massive necrosis of bone and bone marrow occurring as the only, or largely predominant abnormality **(usually due to systemic factors)**

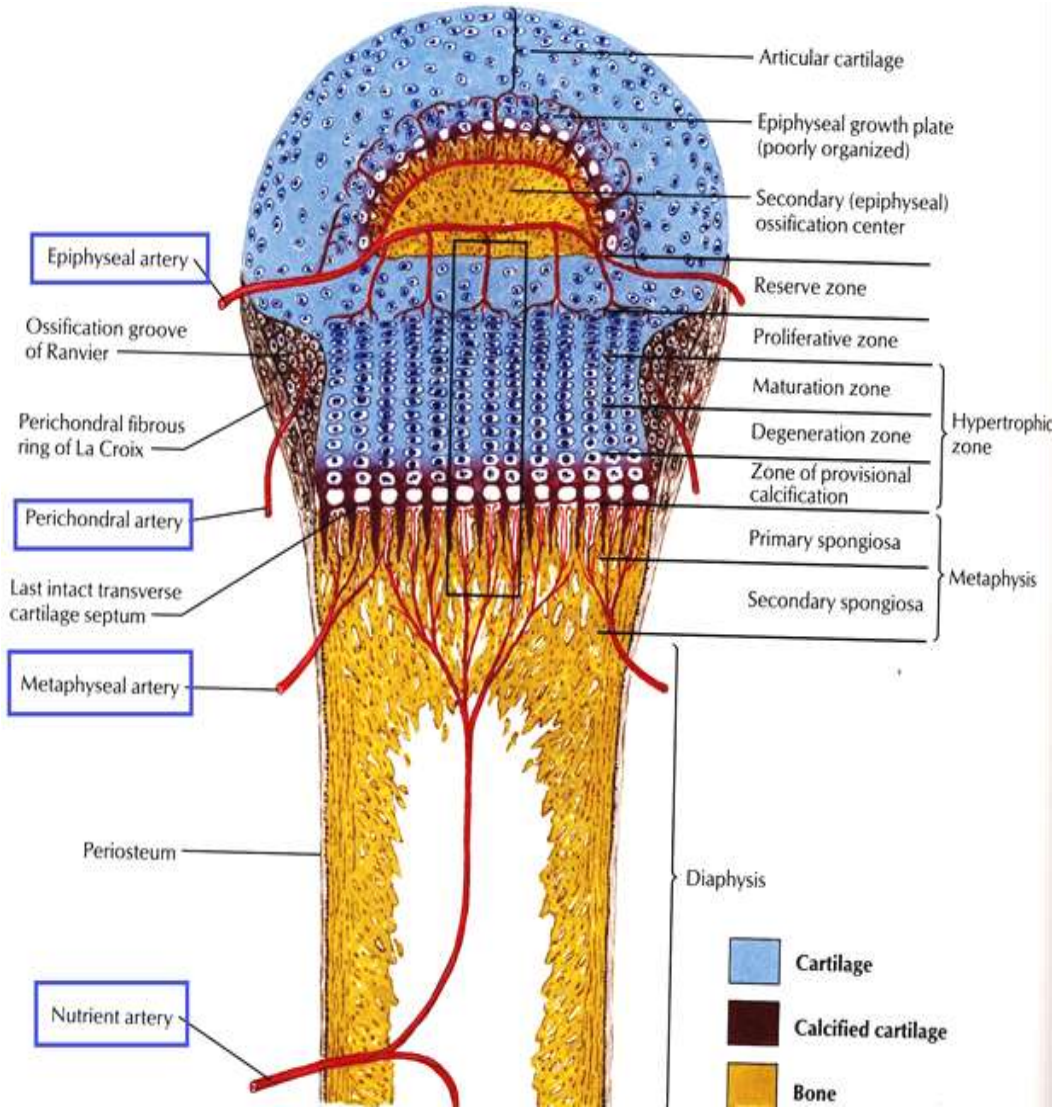


Local AVN (osteonecrosis)

- trauma or microtrauma
- vertebral osteonecrosis
- idiopathic
- small bones
- iatrogenic

Blood supply of immature long bones

1) Metaphyseal vessels
2) Proper nutrient arteries
3) Periosteal vessels
4) Epiphyseal arteries
5) Perichondral arteries



The Physiology of Bone Blood Flow: A Review

Ian McCarthy
J Bone Joint Surg Am. 2006;88:4-9. doi:10.2106/JBJS.F.00890

- Multiple vascular pathways contribute to an adaptive response to traumatic disruption of bone circulation.
- The microcirculation is not merely a passive conduit for blood flow, but plays an active role in controlling bone processes
- The gold standard for experimental measurement of bone blood flow is the **radioactive microsphere technique**

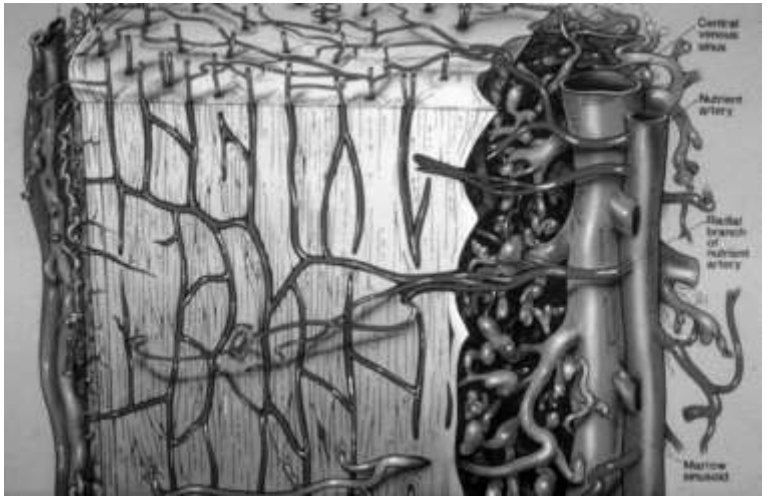


TABLE I Typical Values of Blood Flow in Different Regions of Bone

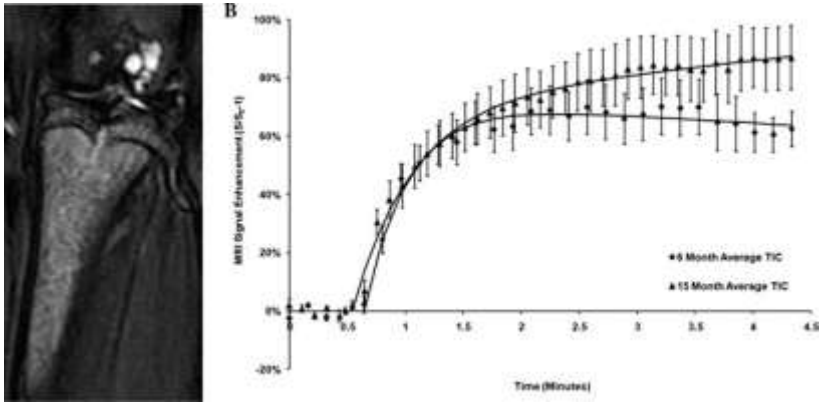
	Blood Flow (mL/min/100 g)
Cortical bone	5
Cancellous bone	20
Cortical marrow	1
Periosteum	5

ANNALS OF THE NEW YORK ACADEMY OF SCIENCES
Issue: *Skeletal Biology and Medicine*

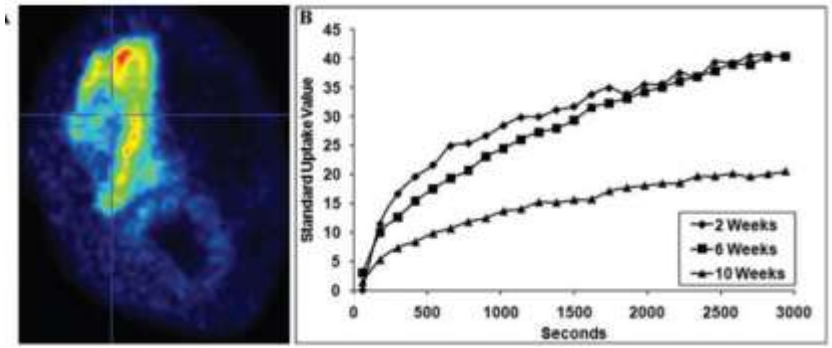
Noninvasive methods of measuring bone blood perfusion

J.P. Dyke[1] and R.K. Aaron[2]

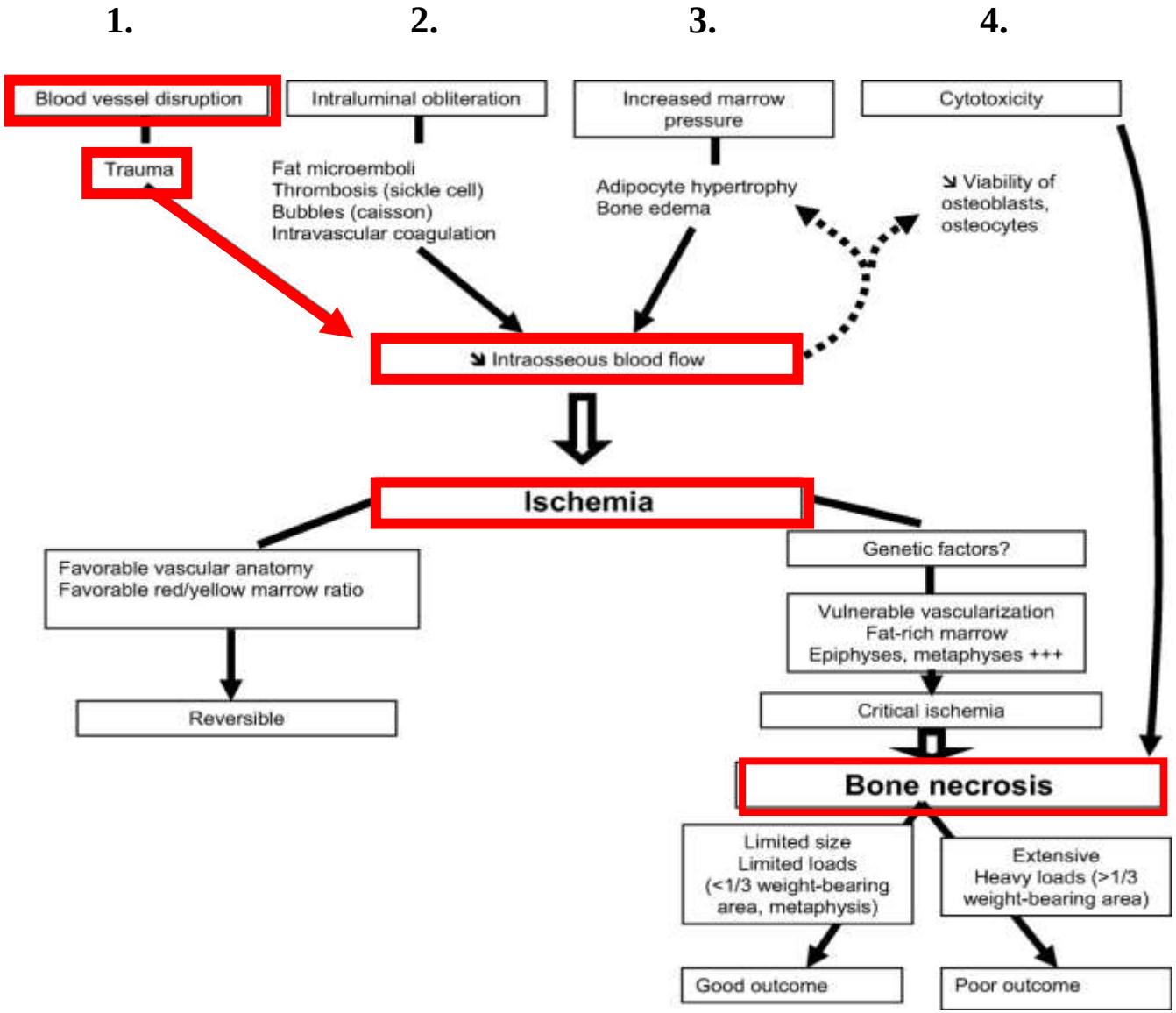
- Measurement of **perfusion** within the bone with dynamic contrast-enhanced MRI in models of osteoarthritis and the femoral head



- Bone **blood flow and remodeling** using ^{18}F-Fluoride PET in fracture healing and osteoarthritis



Mechanisms for development of osteonecrosis



Pathophysiology of Osteonecrosis

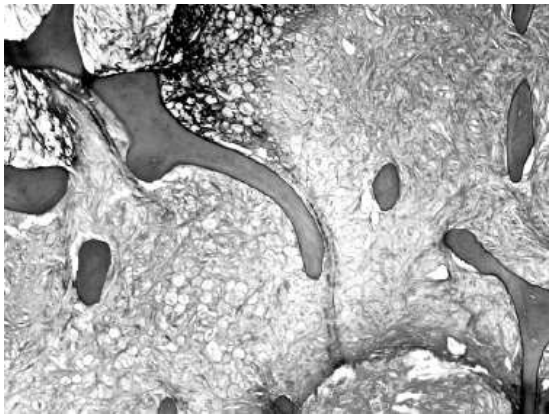
Henry J. Mankin, MD

Semin Arthro 18:170-174 © 2007 Elsevier Inc.

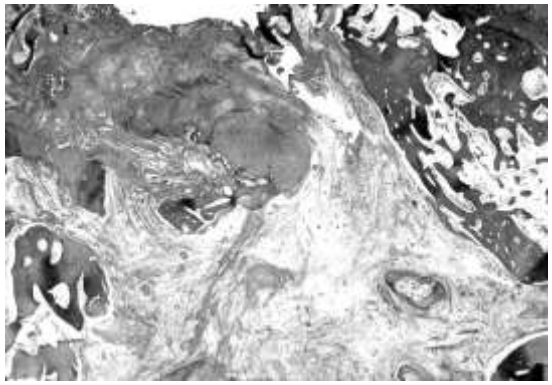
Seminars in Arthroplasty

2 types of osteonecrotic disorders

a) **Medullary** osteonecrosis is caused by interference in the blood supply to the medullary cavity, which results in trabecular bone and cells death (main lipocytes)



b) **Corticocancellous** osteonecrosis involving a joint. The trabeculae and often the subchondral bone both die, and the region does not calcify as occurs in medullary disease, since there are far fewer lipocytes in these regions



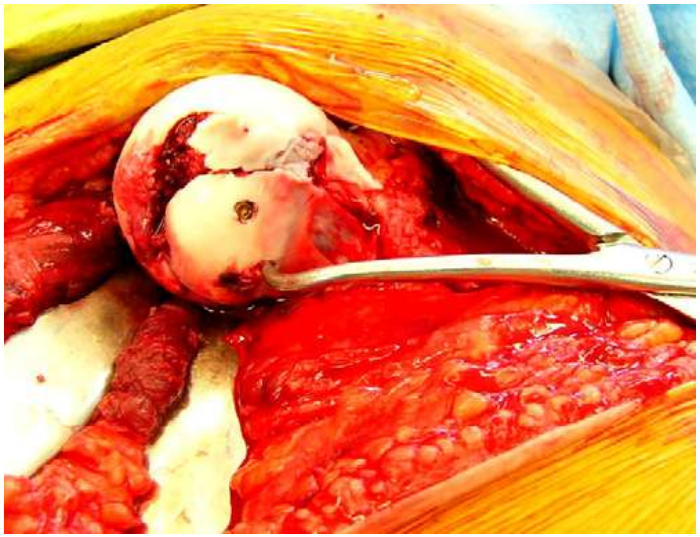
Causes of bone necrosis

Idiopathic - Secondary

Traumatic

Microtrauma or unclear

Iatrogenic -Postoperative



Traumatic osteonecrosis of the hip

16% nondisplaced subcapital fractures

27% displaced subcapital fractures

3% anterior hip dislocations

13% posterior hip dislocations

Transcervical fractures and compression fractures of the femoral head also may lead to osteonecrosis

Anatomy of the medial femoral circumflex artery and its surgical implications

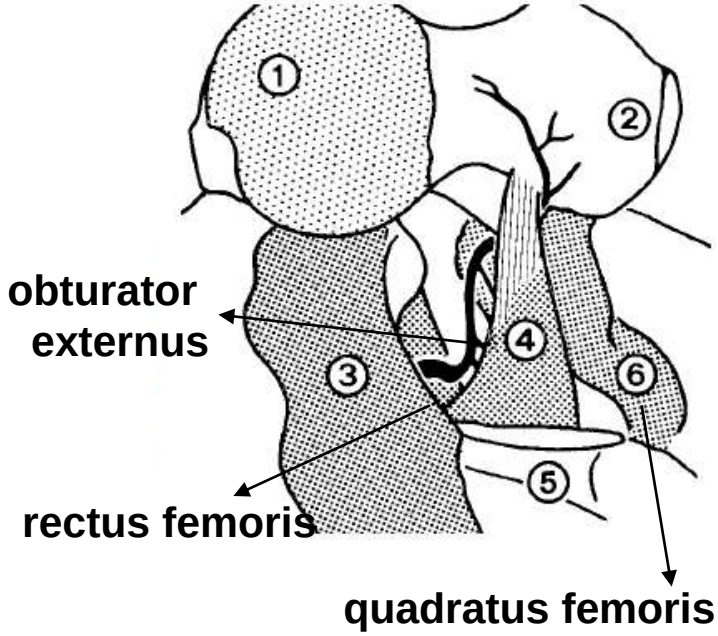
Emanuel Gautier, Katharine Ganz, Nathalie Krügel, Thomas Gill, Reinhold Ganz

J Bone Joint Surg [Br] 2000;82-B:679-83

deep branch of the MFCA during **hip dislocation:**

After complete capsulectomy and tenotomy of all external rotators, except for the tendon of **obturator externus**, the head of the femur is dislocated with external rotation

There is no stretch or compression of the deep branch of the MFCA during dislocation and the normal course of the vessel remains unchanged. Obturator externus and its tendon protect the vessel.

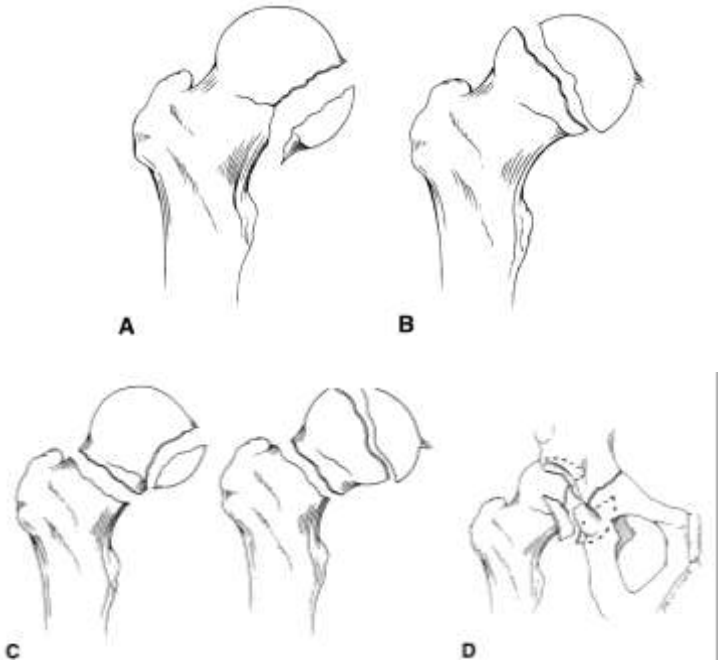


Traumatic osteonecrosis of the hip

Association of femoral head fractures with posterior hip dislocation ranges from 4% to 17%.

A first classification of these fracture dislocations was proposed by **Pipkin** in 1957

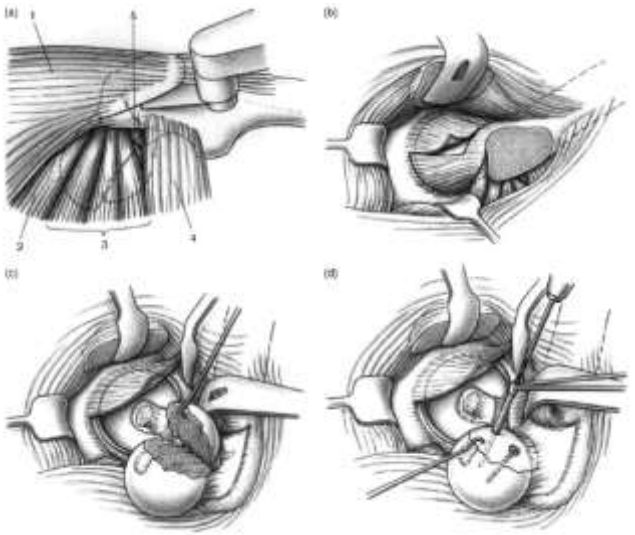
It is classified according to the location of the head fracture in relation to the fovea



Femoral head injuries: Which treatment strategy can be recommended?

Philipp Henle [a], Peter Kloen [b], Klaus A. Siebenrock [a,*]

Injury, Int. J. Care Injured (2007) 38, 478–488



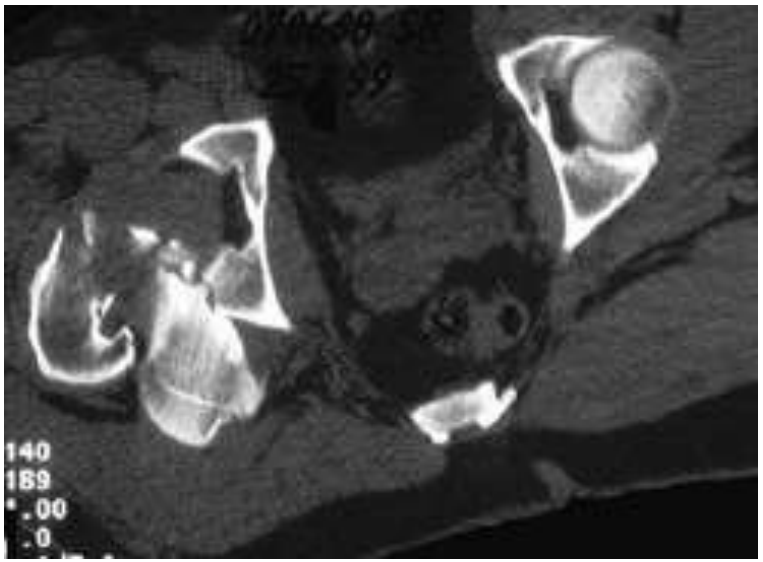
New surgical approach for better access and visualisation for the treatment of femoral head fractures, using the **"trochanteric flip" osteotomy**

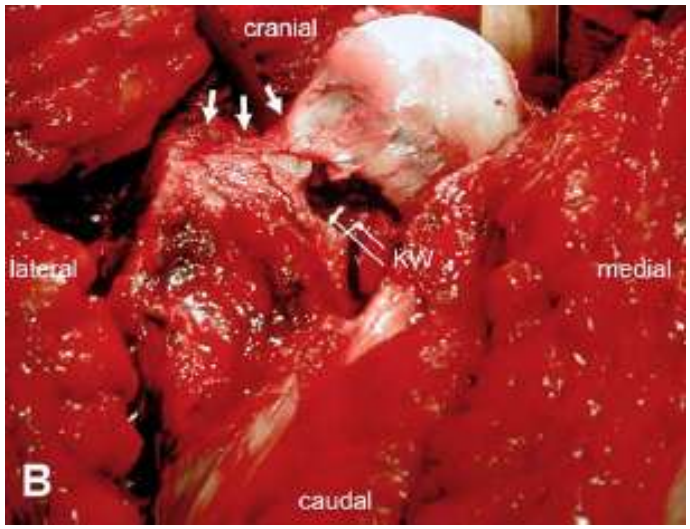
Thus inspection of the entire hip joint and accurate fragment reduction under direct visual control are possible

Hip dislocation and femoral neck fracture: Decision-making for head preservation

Moritz Tannast [a,*], Philip W. Mack [b], Bernd Klaeser [c], Klaus A. Siebenrock [a]

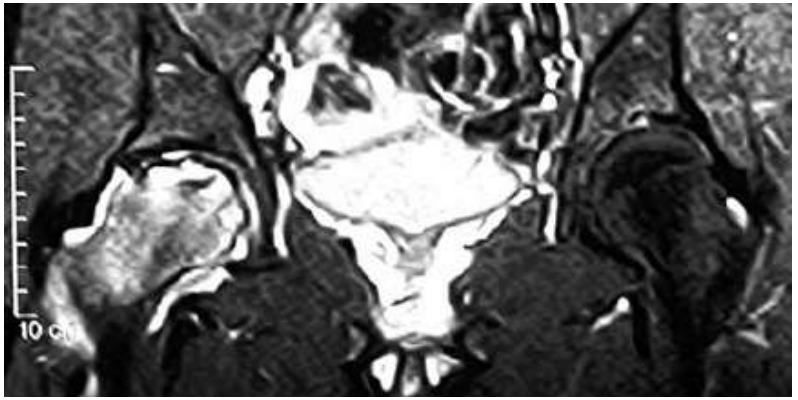
Injury, Int. J. Care Injured 40 (2009) 1118–1124





Osteonecrosis of the Femoral Head After Retrograde Intramedullary Nailing of a Femoral Shaft Fracture in an Adolescent. A Case Report

Darren A. Frank, Robert A. Gallo, Gregory T. Altman and Daniel T. Altman
J Bone Joint Surg Am. 2005;87:2080-2085. doi:10.2106/JBJS.D.02774



Type I open fracture of the R femur in a polytrauma patient. Hypovolemic shock was propably the cause of AVN

Avascular Necrosis of the Femoral Head in Pertrochanteric Fractures

A Report of 8 Cases and a Review of the Literature

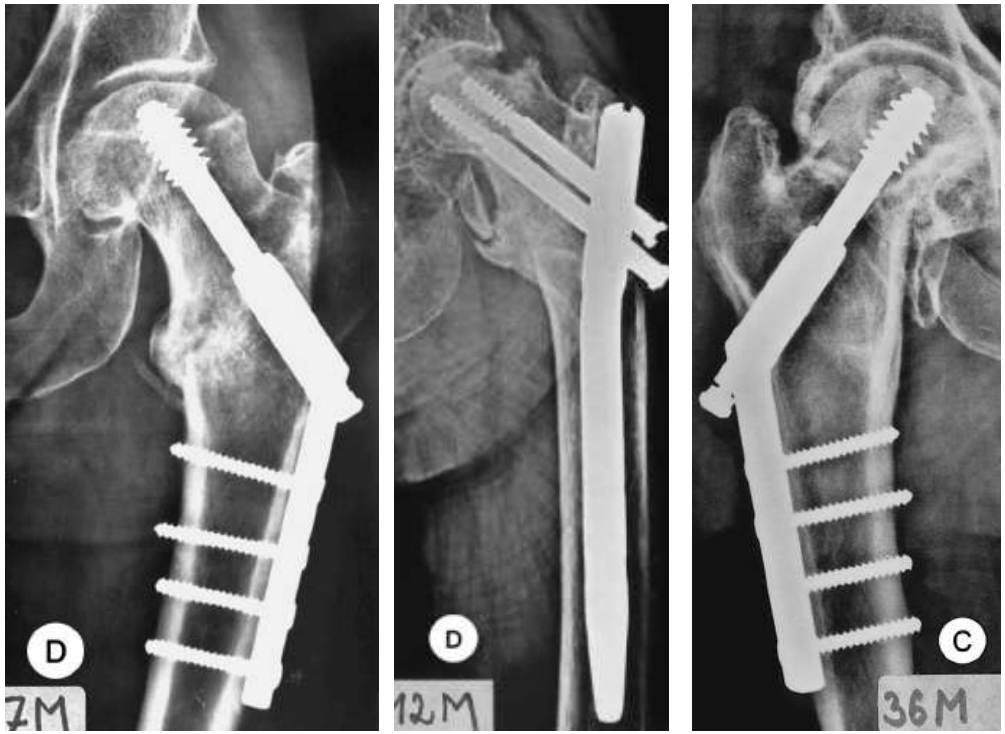
Jan Bartoníček, MD, Vladimír Frič, MD, Jiří Skála-Rosenbaum, MD, and Pavel Douša, MD

(*J Orthop Trauma* 2007;21:229–236)

- ANFH develops in 0.5–1% of all pertrochanteric fractures

- mostly within 4 years after the injury

- patients older than 50 years of age



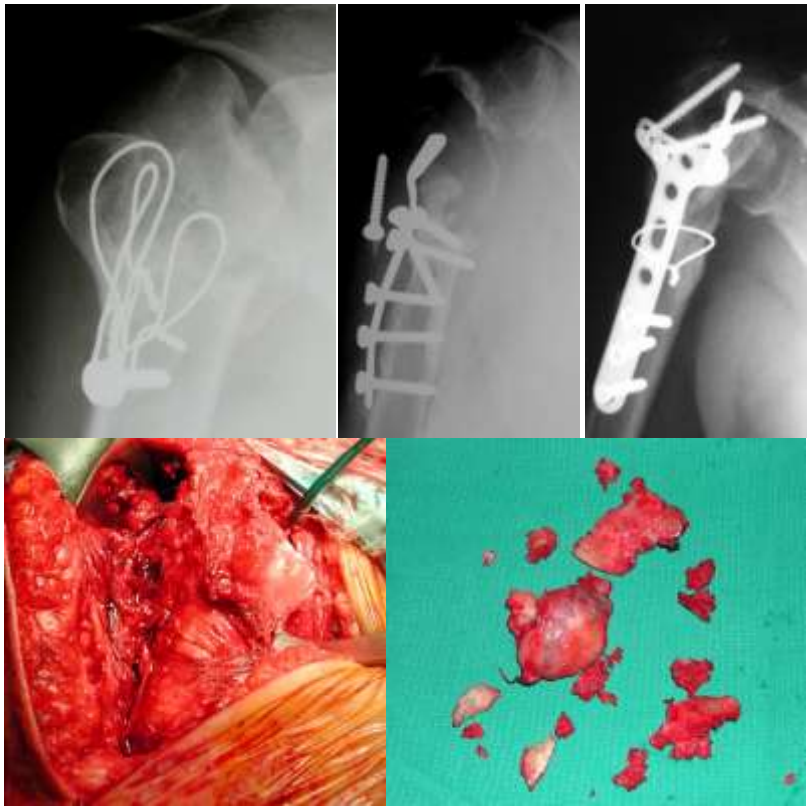
Traumatic osteonecrosis of the humeral head

Results from disruption of the blood supply caused by fracture and/or dislocation

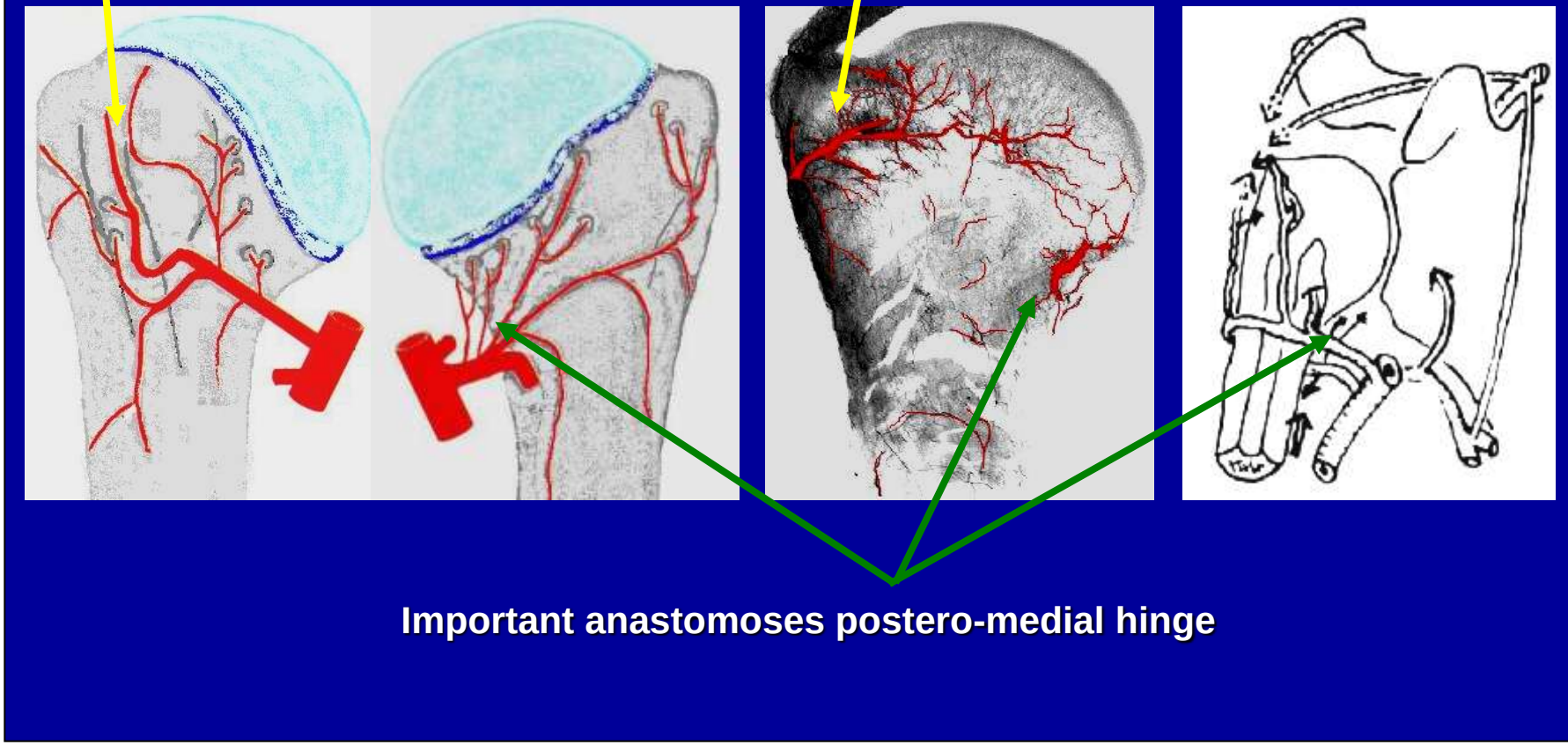
34% of 3-part fractures

90% of 4-part fractures

Almost 100% in splitting head fractures

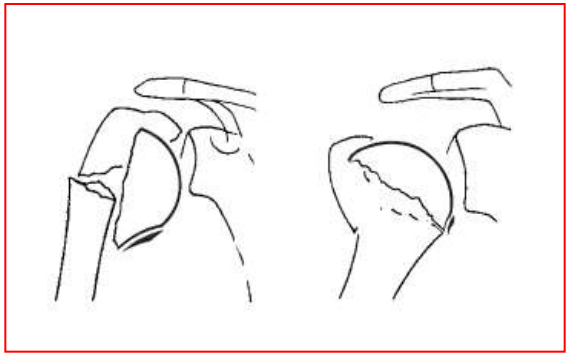


Traumatic osteonecrosis of the humeral head

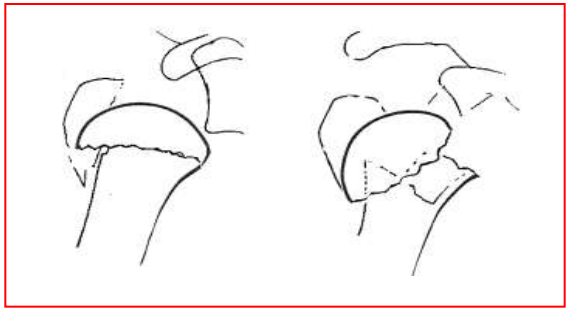


Ischemia predisposition factors

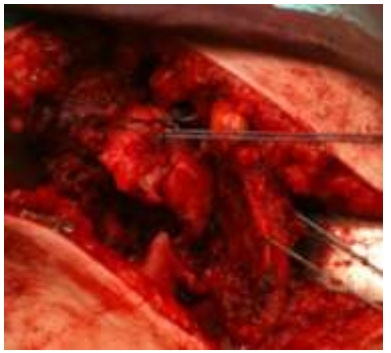
- a) length of medial metaphyseal head extension (< 8 mm in ischemic heads)



- b) integrity of the medial hinge (43 / 55 ischemic heads > 2 mm)



- c) splitting head component



Hertel R, et al. JESS 2004

International Orthopaedics (SICOT) (2004) 28: 333–337
DOI 10.1007/s00264-004-0581-y

ORIGINAL PAPER

Andreas M. Panagopoulos · P. Dimakopoulos · M. Tyllianakis · D. Karnabatidis · D. Siablis · A. X. Papadopoulos · E. Lambiris · P. Kraniotis · G. Sakellaropoulos

Valgus impacted proximal humeral fractures and their blood supply after transosseous suturing

University hospital Patras 2000-2002

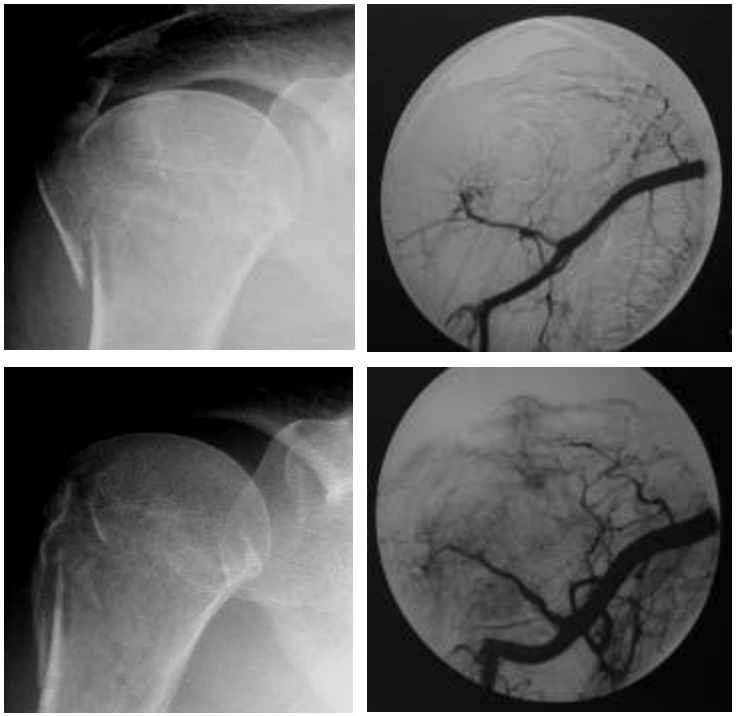
16 patients with 4-part VI fractures

11 women, 5 men (AA 44.6 Y)

Preop and postop (8-10/52) angiography

Transosseous suturing

Mean fup 40 months



Impaction angle (mean 42.4^{o})

Medial hinge integrity (mean 1.4 mm)

International Orthopaedics (SICOT) (2004) 28: 333–337
DOI 10.1007/s00264-004-0581-y

ORIGINAL PAPER

Andreas M. Panagopoulos · P. Dimakopoulos · M. Tyllianakis · D. Karnabatidis · D. Siablis · A. X. Papadopoulos · E. Lambiris · P. Kraniotis · G. Sakellaropoulos

Valgus impacted proximal humeral fractures and their blood supply after transosseous suturing

Image processing

Segmentation technique

Area of interest (AOI)

Thresholding

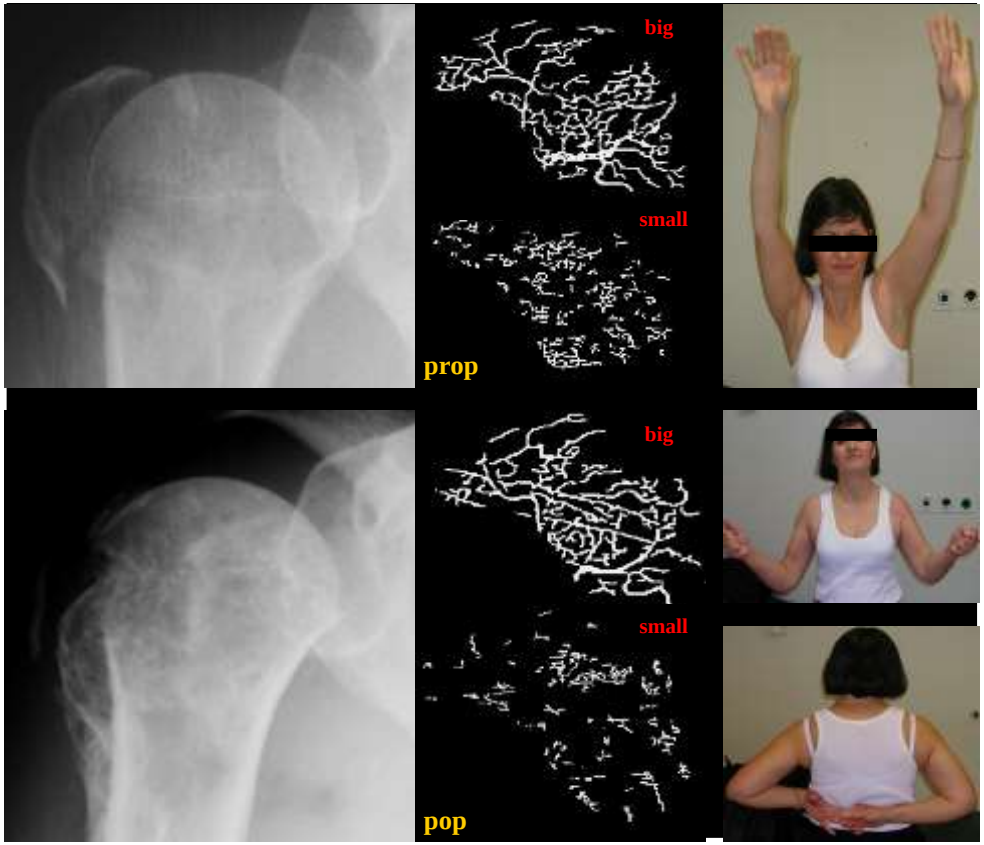
Sobel filters

↓ artifacts

Sharpening

Masks

"big vessels" = diameter > **0.5**

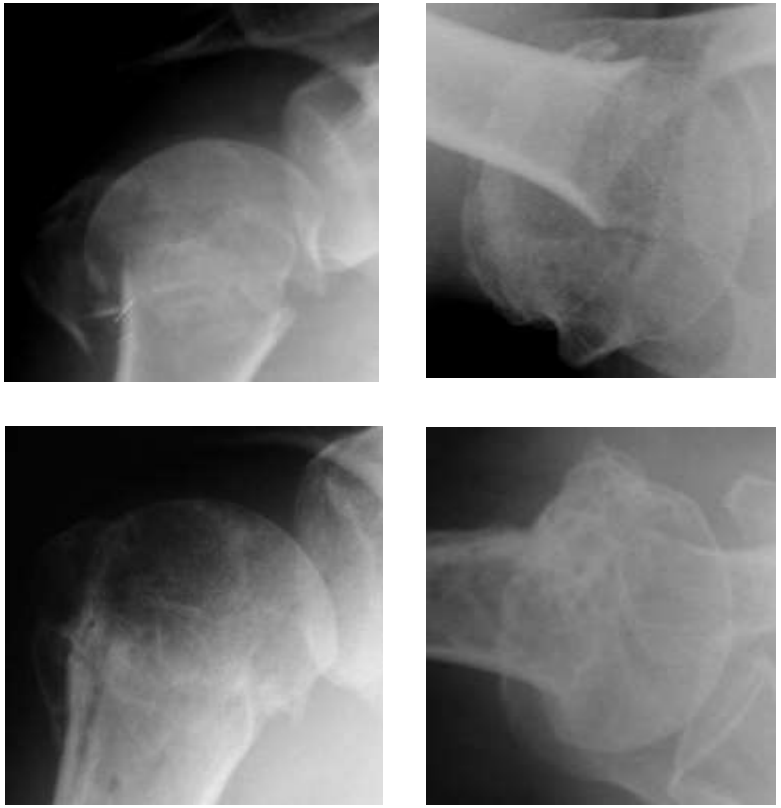


Transosseous Suture Fixation of Proximal Humeral Fractures

Panayiotis Dimakopoulos, Georgios Kasimatis and Andreas Panagopoulos
J Bone Joint Surg Am. 2007;89:1700-1709. doi:10.2106/JBJS.F.00765

- Malunion was present in nine patients (5%) at the time of the last follow-up……

- Humeral head **osteonecrosis** was seen in eleven (7%) of the 165 patients; four demonstrated total and seven, partial collapse.

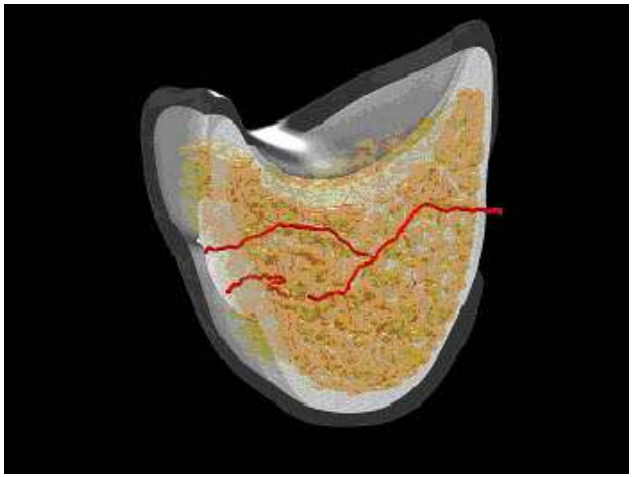


Kienbock's disease

Kienbock's disease is caused either by repeated minimal trauma or a single acute episode.

↑ incidence involves frequent impact to the wrist, such as hammering

74% negative ulnar variance



70% of lunates, multiple vessels in a or Y pattern
30% (I pattern), these lunates at increased risk

J Hand Surg 2009;34A:167–175

CURRENT CONCEPTS

Kienböck's Disease

Pedro K. Beredjiklian, MD

TABLE 1. Lichtman Classification of Kienböck's Disease

Stage 1	Normal x-ray, signal intensity changes on MRI
Stage 2	Lunate sclerosis on plain x-ray; fracture lines may be present
Stage 3	Collapse of the lunate articular surface
Stage 3A	Normal carpal alignment and height
Stage 3B	Fixed scaphoid rotation, proximal capitate migration, loss of carpal height
Stage 4	Lunate collapse along with radiocarpal or midcarpal arthritis

Modified from Allan CH, Joshi A, Lichtman DM. Kienbock's disease: diagnosis and treatment. J Am Acad Orthop Surg 2001;9:128–136.

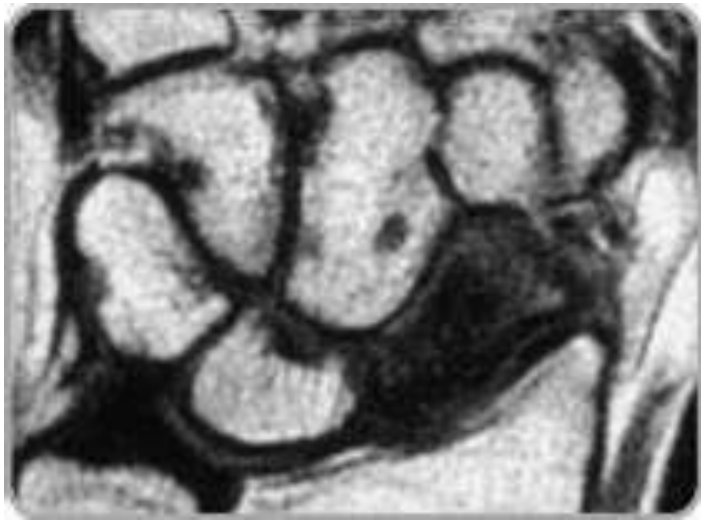
TABLE 2. Treatment of Kienböck's Disease According to Stage

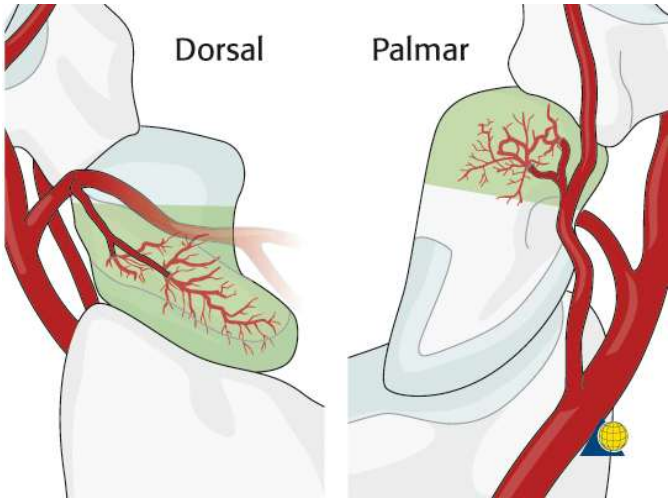
Stage 1	Cast immobilization for 3 months
Stage 2 to 3A, ulnar negative variance	Radial shortening; ulnar lengthening; capitate shortening
Stage 2 to 3A, ulnar positive variance	Vascularized bone graft and external fixation; radial wedge or dome osteotomy; capitate shortening
Stage 3B	Intercarpal arthrodesis (scaphotrapezio-trapezoidal, scaphocapitate); lunate excision; radial shortening; proximal row carpectomy
Stage 4	Proximal row carpectomy; wrist arthrodesis; wrist denervation

Preiser's disease

Or post-traumatic AVN of the scaphoid?

Repeated microtrauma maybe a causative factor





Idiopathic osteonecrosis of the scaphoid (Preiser's disease) – MRI gives new insights into etiology and pathology

R. Schmitt[a,*], S. Fröhner[a], J. van Schoonhoven[b], U. Lanz[c], A. Gölles[a]

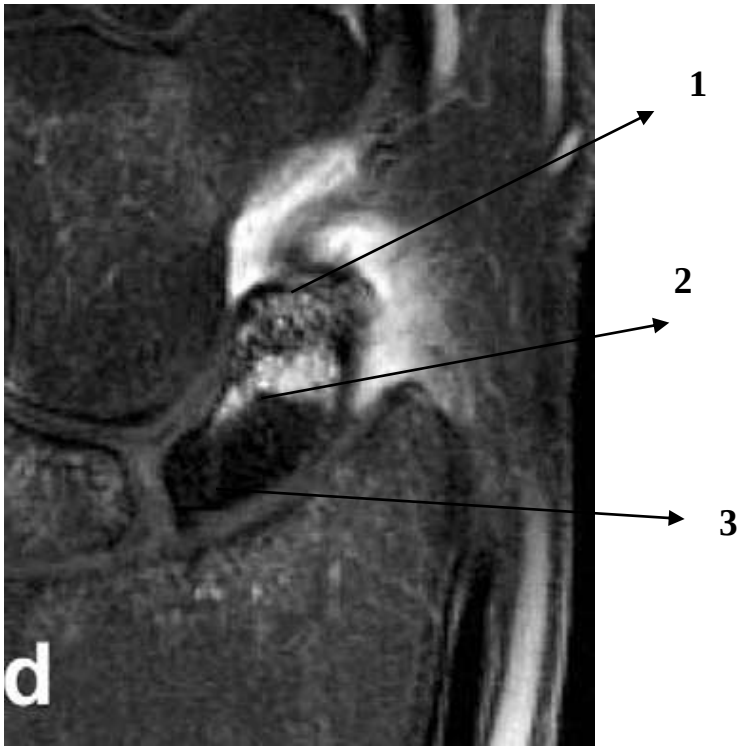
European Journal of Radiology 77 (2011) 228–234

3 pathoanatomical zones are differentiated

1. the proximal scaphoid pole is the "**zone of osteonecrosis**" in Preiser's disease

2. the middle scaphoid section in Preiser's disease is the **"zone of repair"**

3. the distal scaphoid section is affected late and bone marrow viability is maintained over a long period representing the **"zone of viability".**



Kümmell's disease

OSTEOPOROSIS

ORTHOPEDICS January 2008;31(1):61.

Osteoporotic Vertebral Fractures and Collapse With Intravertebral Vacuum Sign (Kümmel's Disease)

by Ioannis p. Pappou, MD; Elias C. Papadopoulos; Andrew N. Swanson; Frank P. Cammisa, MD; Federico P. Girardi, MD

The intravertebral vacuum sign was first described by Kümmell in 1895.

Several terms have been used to describe this phenomenon, including intravertebral vacuum, delayed vertebral collapse, vertebral **osteonecrosis** and vertebral pseudarthrosis

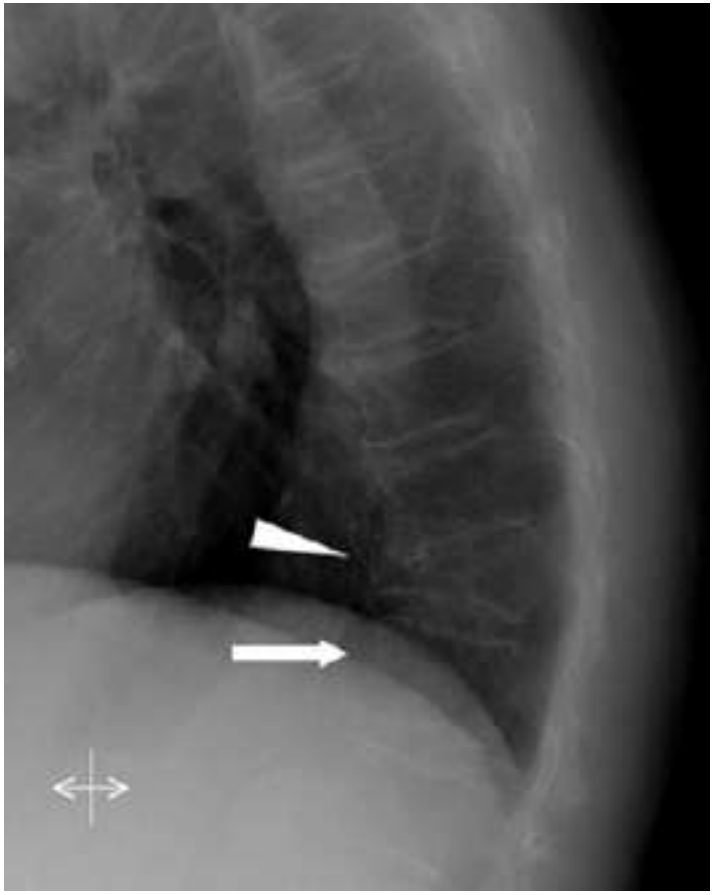
A fracture of the osteoporotic bone could lead to necrosis, Alternatively, ischemia/necrosis of the weakened osteoporotic bone could cause a fracture.

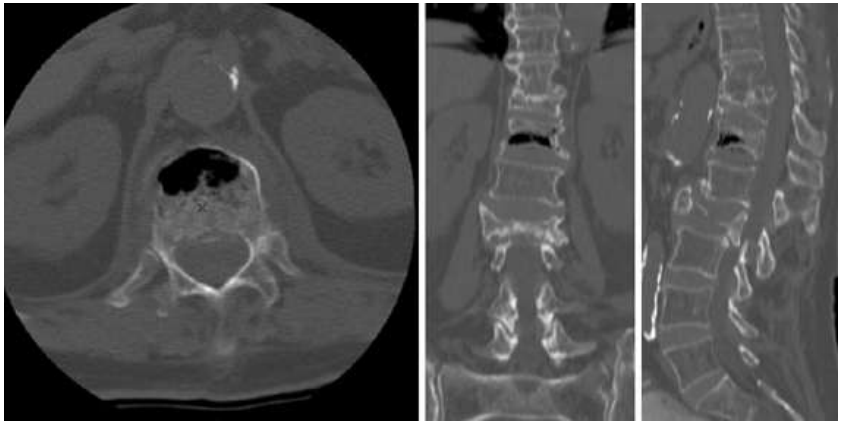
Eur Spine J (2010) 19:1065–1070
DOI 10.1007/s00586-009-1205-4

GRAND ROUNDS

Kummell's disease: delayed post-traumatic osteonecrosis of the vertebral body

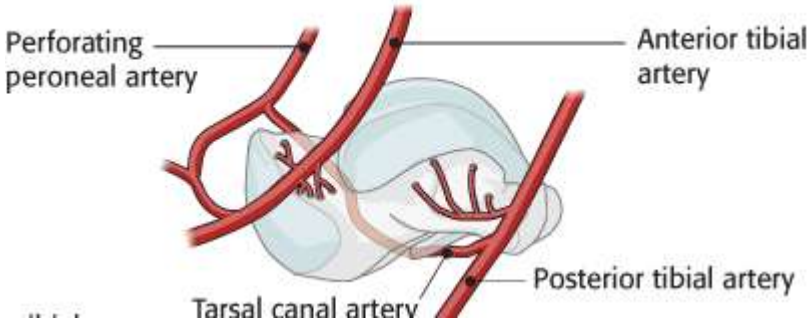
Richard Ma · Robert Chow · Francis H. Shen





Post-traumatic osteonecrosis of the talus

It has been suggested that initial fracture displacement and delayed fracture fixation are associated with an increased incidence of osteonecrosis



HAWKINS classification

Type I (0-20%)

Type II (20-50%)

Type III (~100%)

Type IV (100%)

Talar Neck Fractures: Results and Outcomes

Heather A. Vallier, Sean E. Nork, David P. Barei, Stephen K. Benirschke and Bruce J. Sangeorzan
J Bone Joint Surg Am. 2004;86:1616-1624.

Osteonecrosis with collapse of the dome occurred in twelve (31%) of thirty-nine patients.
Osteonecrosis was seen in association with nine (39%) of twenty-three Hawkins group-II fractures and nine (64%) of fourteen Hawkins group-III fractures.

The mean time to fixation was **3.4 days** for patients who had development of osteonecrosis, compared with 5.0 days for patients who did not have development of osteonecrosis

Does a Longer Delay in Fixation of Talus Fractures Cause Osteonecrosis?

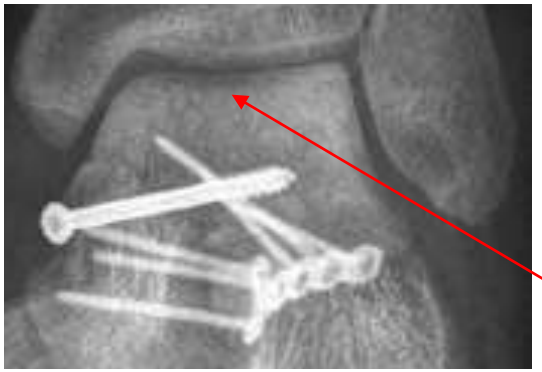
(Journal of Surgical Orthopaedic Advances 20(1):34–37, 2011)

CPT Jaime L. Bellamy, DO,[1] CDR John J. Keeling, MD,[2] Joseph Wenke, PhD,[3]
LTC Joseph R. Hsu, MD,[3] and the Skeletal Trauma Research Consortium

Mean delay in fracture fixation 12.9 days

Hawkins sign in 59% of fractures at a mean of 7 weeks.

AVN developed in 7 of 17 fractures, with mean fixation time of 12.5 days; Hawkins sign was present in 20%.



Osteonecrosis after arthroscopic surgery

Humeral Head Osteonecrosis After Anterior Shoulder Stabilization in an Adolescent. A Case Report

Dhruv B. Pateder, Hyung Bin Park, Efstathios Chronopoulos, Laura M. Fayad and Edward G. McFarland
J Bone Joint Surg Am. 2004;86:2290-2293.

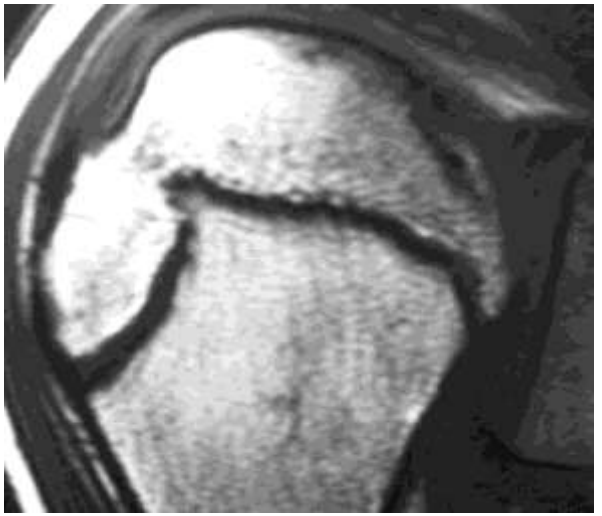
13 year-old patient

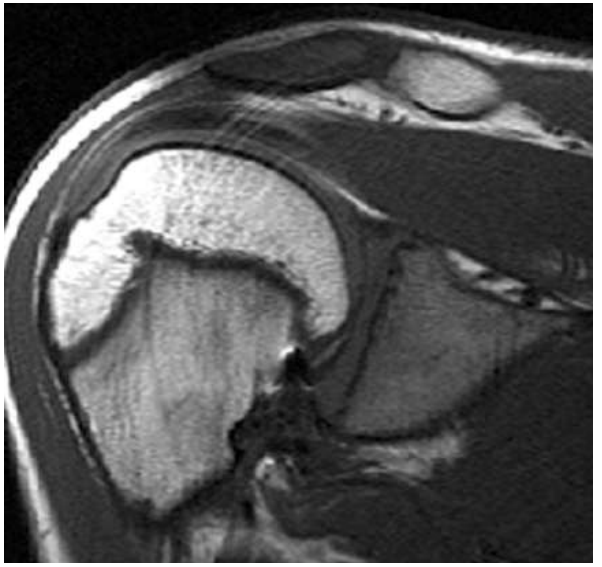
Avulsion of GH ligaments

Diagnostic arthroscopy/Open repair

6 weeks after surgery

Resolved spontaneously in 12 months





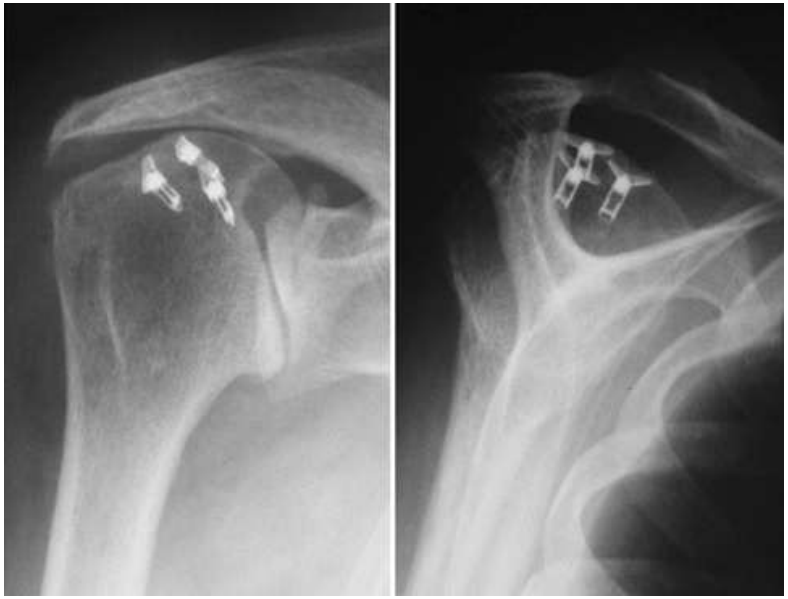
Knee Surg Sports Traumatol Arthrosc (2010) 18:1432–1434
DOI 10.1007/s00167-009-1016-5

SHOULDER

Humeral head osteonecrosis following arthroscopic rotator cuff repair

V. Beauthier · S. Sanghavi · E. Roulot · P. Hardy

…The presented shoulder necrosis may have occurred due to the use of multiple anchors which may have interrupted blood supply of the anteroinferior part of the head…….



Arthroscopy: The Journal of Arthroscopic and Related Surgery, Vol 23, No 4 (April), 2007: pp 428-438

Current Concepts

Postarthroscopic Osteonecrosis of the Knee

Dietrich Pape, M.D., Romain Seil, M.D., Koustantiuos Anagnostakos, M.D., and Dieter Kohn, M.D.

First report by Brahme et al. in 1991 (after routine arthroscopic meniscectomy)

Current terminology **ONPK** (..SPONK)

ONPK after arthroscopic meniscectomy has been reported in 9 clinical studies with a total of 47 patients (2007)

Both genders were equally affected with a mean age of 58 years

87% of pt medial meniscus tear

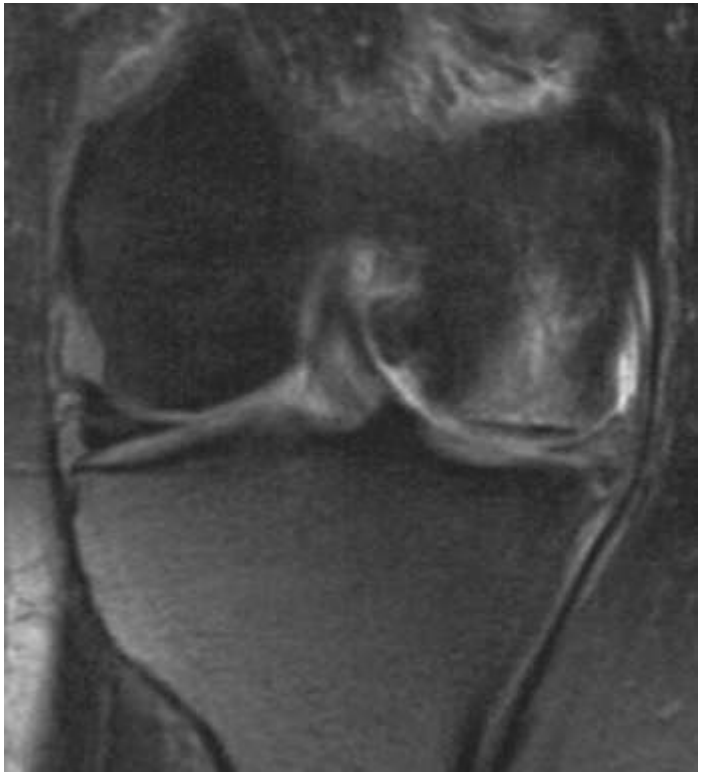
OPNK - pathophysiology

The etiology of ONPK remains unclear.

The **meniscal tear itself** seems to have an association with osteonecrosis even before surgery has been performed

Increased tibiofemoral contact pressure after meniscectomy may predispose to fracture of the cartilage and subchondral bone with an intraosseous leak of synovial fluid and subsequent osteonecrosis.

The **pathologic cartilage** has increased permeability for the arthroscopy fluid, which might lead to subchondral edema and consequent



OPNK – differential diagnosis

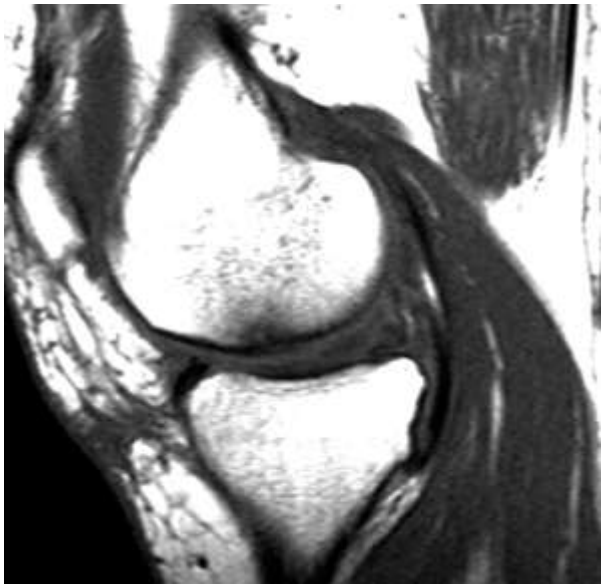
In patients with persistent or worsening symptoms after knee arthroscopy:

(1) a missed diagnosis of early-stage osteonecrosis of the knee (SPONK),

(2) ONPK,

(3) a transient lesion that shares the BME pattern on MRI with SPONK and ONPK, and

(4) a recurrent meniscal tear



OPNK – differential diagnosis

Difficult to distinguish OPNK from SPONK in preop MRI

TABLE 5. *Five Radiographic Stages of SPONK*

Stage	Findings on Plain Radiography	Time Interval Since Onset of Symptoms
1	Normal	Several months
2	Flattening of the affected weight-bearing portion of the femoral condyle	Several months
3	Pathognomonic lesion consisting of an area of radiolucency of variable size and depth and surrounded proximally and distally by some sclerosis, frequently found as the "earliest" radiologic sign of SPONK	Up to 1 yr
4	Radiolucent area surrounded by sclerotic halo; subchondral bone has collapsed and is visible as a calcified plate	Up to 1 yr
5	Secondary degenerative changes of the medial compartment with joint space narrowing, subchondral sclerosis, and osteophyte formation associated with some erosion	More than 2 yr

In elderly patients delay MRI exam up to 6 weeks after onset

Clin Orthop Relat Res (2010) 468:3121–3125
DOI 10.1007/s11999-010-1256-1

CASE REPORT

Case Report

Osteonecrosis of the Femoral Head after Hip Arthroscopy

Danielle L. Scher MD, Philip J. Belmont Jr MD,
Brett D. Owens MD

….the cause of femoral head osteonecrosis in our patient may have been secondary to disruption of the primary blood supply to the femoral head during **portal placement** or we believe more likely as a result of a **traction injury**.