Introducción

Osteonecrosis de la cabeza femoral involucra la articulación del cuello femoral, con osteocitos de la cabeza femoral muriendo junto con el tejido adyacente; la resorción de la materia muerta por un nuevo pero más débil tejido óseo puede llevar a una fractura subcondral y colapso. Hay dos formas de osteonecrosis: traumática (la forma más común) y no traumática. Otros términos para describir este trastorno son necrosis avascular e isquémica para denotar la etiología vascular. El término necrosis no séptica también ha sido utilizado para indicar que la infección no desempeña un papel causativo.

Alexander Munro first identified the condition in 1738. In the mid 1800s, Cruveilhier was the first to attribute the disorder to an aberration of circulation in the femoral head. Diagnosis of this disorder has increased because of improved technology and increased awareness.

Problem

Osteonecrosis is now a commonly recognized disorder with significant morbidity. The end stage of the process is severe destruction of the femoral head with resultant degeneration of the hip joint. In many patients, even early identification and intervention do not alter the result. Unfortunately, patients who are affected with osteonecrosis are young, usually in the third to sixth decades of life.

Traumatic and atraumatic osteonecrosis are essentially 2 distinct problems. The traumatic form has a definitive causal event and is isolated to the particular injured bone. The atraumatic form has multiple etiologies and can involve multiple bones. The main focus of this article is atraumatic osteonecrosis.

Etiología

As the name implies, traumatic osteonecrosis is secondary to direct injury to the femoral head with resultant damage of the blood supply. Fracture of the femoral head or neck and hip dislocation are the primary mechanisms of injury.

Atraumatic osteonecrosis has many risk factors. The 2 most commonly associated problems are corticosteroid use and alcohol abuse. The idiopathic cases make up the third most common category. Other factors include sickle cell anemia, Gaucher disease, systemic lupus erythematosus, coagulopathies, hyperlipidemia, organ transplantation, caisson disease, and thyroid disorders. Genetic factors may also play a role.
Hip osteonecrosis resulting from corticosteroid use or alcohol abuse is associated with the worst prognosis. Frequently, steroid-induced osteonecrosis involves multiple bones and, in the case of the hip, results in nearly 100% bilateral involvement. The exact dose required to induce osteonecrosis remains an enigma, but most studies indicate that higher doses, even over a short duration, present the highest risk. Often, patients on steroids have other associated risk factors.

Osteonecrosis associated with alcohol abuse usually occurs in those who drink more than 400 mL of alcohol per week. It is more common in those with a long-term history of heavy consumption.

**Pathophysiology**

Traumatic osteonecrosis is a direct result of disruption of the blood supply to the femoral head. Death of bone marrow occurs within 6-12 hours after vascular insult. Death of the bone becomes apparent several days later.

The pathophysiology in atraumatic osteonecrosis remains controversial. Fat cell hypertrophy with resultant pressure increase within the femoral head, leading to vascular collapse and then necrosis, has been proposed as a mechanism for steroid-induced osteonecrosis. A fat embolism phenomenon with resultant vascular occlusion is another proposed mechanism. A hyperlipidemic state seems to be related to causation, but the exact mechanism is unknown. Similarly, the lipid hypothesis has also been applied to cases associated with alcohol abuse.

In caisson disease, circulating nitrogen bubbles occlude blood vessels in response to reduction in ambient pressure during decompression. Sickle cell anemia results in bone death secondary to the sickling process and subsequent vascular occlusion.

Increased intraosseous pressure contributes directly to the propagation of necrosis, regardless of etiology. As bone death occurs, a repair process takes place as dead bone is removed and replaced by new bone. During this phase, the bone underlying the joint surface is weakened. In most patients, subchondral fracture alters the articular surface, resulting in abnormal mechanics and arthritic alterations to the joint.

The disease affects both sides of the joint, as confirmed by PET scan imaging showing earlier involvement in the acetabulum than is discernible by other radiographic modalities.

**Presentation**

Patients with osteonecrosis usually are men in the sixth decade of life who experience pain primarily in the groin but occasionally the buttocks. Pain usually is deep and throbbing and is worse with ambulation, but it also is significant at night. Onset often can be described as acute. Patients frequently describe a catching or popping sensation with motion. A history of trauma, steroid use, alcohol abuse, and other risk factors should be sought.

Physical examination reveals pain with range of motion and ambulation. Limitation of internal rotation in both flexion and extension are prevalent, with passive internal rotation in extension being particularly painful. A Trendelenburg gait often is present.

Plain radiographic findings frequently are normal. Therefore, a high index of suspicion should arise based on the history and physical.

**Indications**

History and physical examinations are paramount for diagnosis. Treatment is indicated after diagnosis is confirmed with radiographic studies. Most studies indicate that the risk for disease progression is greater with nonsurgical treatment than with surgical intervention.
**Relevant Anatomy**

Blood is supplied to the femoral head primarily from branches of the medial and lateral circumflex vessels, which arise from the femoral artery. The retinacular branches deep to the posterior capsule are the most important. Blood also is supplied from the obturator artery.

**Contraindications**

There are few contraindications to surgical treatment of osteonecrosis. Obvious disorders aside (eg, severe systemic disease, systemic sepsis), those afflicted often are young and have few surgical contraindications.

**Workup**

**Laboratory Studies**

- Lab tests have limited utility in the diagnosis of osteonecrosis, with exceptions as follows:
  - Sickle cell testing in African Americans
  - Lipid profile
  - Screening for coagulopathies - Protein S and protein C deficiencies, factor V Leiden disease

**Imaging Studies**

- Anteroposterior (AP) radiographs (see image below) and frog lateral radiographs of both hips are the primary diagnostic modalities.
  - AP and frog lateral tomograms

Osteonecrosis, hip. Anteroposterior radiograph showing Ficat stage III disease.
Indicated if patients have evidence of disease on radiographs but have no collapse

Often helpful in staging

- MRI
  - Sensitivity and specificity is greater than 98%, which is higher than all other modalities.
  - This study is ideal if x-ray findings are normal and clinical suspicion is high. MRI should be performed in all patients with osteonecrosis to assess the extent of the disease. Three-dimensional MRI scanning with image registration may be used to assess changes in lesion size.
  - MRI is recommended to identify bilateral disease when 1 hip has radiographic signs of disease and the other is normal (see image below).

![MRI showing osteonecrosis of right hip, normal left hip.](image)

- Bone scanning (see image below)
Bone scan showing osteonecrosis of right hip.

- Helpful when x-ray findings are normal if MRI cannot be obtained
- Low-cost alternative when index of suspicion is low

**Diagnostic Procedures**

- Core biopsy (see image below) and interosseous pressure measurement
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Osteonecrosis, hip. Anteroposterior radiograph core biopsy.

- An open biopsy of 10-mm core of bone from the femoral head can be used for diagnosis.
- Measurement of interosseous pressure can be obtained before and after biopsy to confirm decompression of intraosseous space.

- Venography
  - Injection of contrast under image intensification has been used as part of the functional evaluation of bone when measuring intraosseous pressure.
  - This can be used to confirm presence of the needle within the head and venous congestion.

**Histologic Findings**

The first histologic findings are marrow and adipocyte necrosis. Next, liquefaction necrosis and interstitial edema occur. Pyknotic nuclei with empty lacunae are identified as osteocyte necrosis occurs. Eventually, the zone of necrosis is surrounded by repair tissue as revascularization proceeds. During this phase, the subchondral plate is weakened as resorption occurs faster than reformation, leading to subchondral collapse and eventual cartilage damage.

**Staging**

Several radiographic staging systems are currently used.
- Ficat classification
  - Stage 0 - No pain, normal radiographic findings, abnormal bone scan or MRI findings
  - Stage I - Pain, normal x-ray findings, abnormal bone scan or MRI findings
  - Stage IIa - Pain, cysts and/or sclerosis visible on x-ray, abnormal bone scan or MRI findings, without subchondral fracture
  - Stage III - Pain, femoral head collapse visible on x-ray, abnormal bone scan or MRI findings, crescent sign (subchondral collapse) and/or step-off in contour of subchondral bone
  - Stage IV - Pain, acetabular disease with joint space narrowing and arthritis (osteoarthritis) visible on x-ray, abnormal MRI or bone scan findings

- Steinberg staging system
  - Stage 0 - Normal or nondiagnostic radiographic, bone scan, and MRI findings
  - Stage I - Normal radiographic findings, abnormal bone scan and/or MRI findings
    - A - Mild: <15% of head affected
    - B - Moderate: 15-30%
    - C - Severe: >30%
  - Stage II - Lucent and sclerotic changes in femoral head
    - A - Mild: <15%
    - B - Moderate: 15-30%
    - C - Severe: >30%
  - Stage III - Subchondral collapse (crescent sign) without flattening
    - A - Mild: <15% of articular surface
    - B - Moderate: 15-30%
    - C - Severe: >30%
  - Stage IV - Flattening of femoral head
    - A - Mild: <15% of surface or <2-mm depression
    - B - Moderate: 15-30% of surface or 2- to 4-mm depression
    - C - Severe: >30% of surface or >4-mm depression
  - Stage V - Joint narrowing and/or acetabular changes
    - A - Mild: Average of femoral head involvement as in stage IV and estimated acetabular
    - B - Moderate involvement
    - C - Severe
  - Stage VI - Advanced degenerative changes

- International classification of osteonecrosis of the femoral head (Association Research Circulation Osseus [ARCO])
  - Stage 0 - Bone biopsy results consistent with osteonecrosis; other test results normal
  - Stage I - Positive findings on bone scan, MRI, or both
    - A - <15% involvement of the femoral head (MRI)
    - B - 15-30% involvement
    - C - >30% involvement
  - Stage II - Mottled appearance of femoral head, osteosclerosis, cyst formation, and osteopenia on radiographs; no signs of collapse of femoral head on radiographic or CT study; positive findings on bone scan and MRI; no changes in acetabulum
    - A - <15% involvement of the femoral head (MRI)
- B - 15-30% involvement
- C - >30% involvement

- Stage III - Presence of crescent sign lesions classified on basis of appearance on AP and lateral radiographs
  - A - <15% crescent sign or <2-mm depression of femoral head
  - B - 15-30% crescent sign or 2- to 4-mm depression
  - C - >30% crescent sign or >4-mm depression

- Stage IV - Articular surface flattened; joint space shows narrowing; changes in acetabulum with evidence of osteosclerosis, cyst formation, and marginal osteophytes

## Treatment

### Medical Therapy

Nonsurgical treatment of osteonecrosis is limited. Observation and protected weight bearing are options. Certain cases of early-stage disease (eg, Ficat stage 1) can be treated successfully with this option. However, most studies indicate that the risk of disease progression is greater with nonsurgical treatment than with surgical intervention.

Nonsteroidal anti-inflammatory drugs can be used to reduce pain and inflammation in patients who cannot have surgery for medical or other reasons or for patients who are undergoing surgical treatment.

Physical therapy can be helpful to restore motion and improve gait.

Electrical stimulation has been used in several centers. In some studies, it has been helpful in treatment prior to femoral head collapse. The benefit of surgical treatment options versus observation is controversial in certain cases. Further study is required.

Pharmacotherapy that addresses the pathophysiology of the disease has had mixed results. Examples include gemfibrozil (Lopid) for hyperlipidemias and nifedipine for vascular disorders. Short-term follow-up (about 24 months) of patients in alendronate studies have demonstrated delayed femoral head collapse.[5]

Extracorporeal shockwave treatment has shown some promise in treating early disease by promoting angiogenesis and bone remodeling.[6]

### Surgical Therapy

The mainstay of treatment for osteonecrosis is surgical. Numerous procedures are available, indicating that no single procedure is distinctly advantageous. Preoperative staging, particularly with collapse of the femoral head, and acetabular involvement are the determining factors for choosing a particular operation.

### Preoperative Details

The choice of procedure is based on preoperative staging. Core decompression and cancellous and cortical bone grafting procedures usually are indicated in Ficat stage IIa or earlier stages. The trapdoor procedure and allograft procedures are indicated for stage IIb or stage III lesions. Osteotomies are used for stage II and stage III disease. Arthrodesis and arthroplasty are utilized primarily for stages III and IV but occasionally are used for stages I and II.

### Intraoperative Details

The objective in core decompression is to stimulate revascularization and decrease pressure within the femoral head. The patient is placed supine on a fracture table. Using image intensification through a lateral incision above the trochanteric ridge, a 10-mm core of bone is removed from the femoral necrotic lesion.
Bone grafting has several techniques.

- **Cancellous bone grafting**: A core decompression is performed. The defect is filled with cancellous bone graft material, usually iliac crest or allograft.

- **Cortical bone grafting**: A core decompression is performed, and a strut graft is placed in the defect under the weightbearing surface of the femoral head. Iliac crest or fibula has been used. Recently, use of a vascularized free fibular graft harvested from the ipsilateral leg with a vascular pedicle inserted into the proximal femoral defect and anastomosed with the lateral circumflex artery has become popular.

- **Osteochondral allograft procedure**: The necrotic area is replaced with a nonvascularized free allograft.

- **Muscle pedicle bone grafting**: This procedure was adapted primarily for traumatic osteonecrosis. Cancellous iliac crest graft is placed in a channel in the infracted region and covered by a graft with the quadratus femoris muscle attached.

- **The growth factors Op-1 (osteogenic protein-1) and rhBMP-2 (recombinant human bone morphogenetic protein-2) may be useful bone grafting adjuncts.**[^7]

- **Implantation of mesenchymal stromal cells is currently under investigation.**[^8]

- **Strut grafting with a tantalum implant, a highly porous metallic cylinder placed in a channel to support subchondral bone.**[^9]

The concept in osteotomy is to rotate the diseased area of the femoral head away from the weightbearing surface. Several different techniques are available.

- **Angular osteotomy**: Varus or valgus flexion usually is performed intertrochanterically and fixed with a plate.

- **Rotational osteotomy**: The head is rotated transtrochanterically, moving the weightbearing surface away from the necrotic lesion.

**Arthrodesis** is fusion of the hip joint. The joint is denuded of articular cartilage, and the femoral head and acetabulum are fixed to create a solid interface.

In arthroplasty, conventional techniques are used with either cemented or cementless implants.

- **Resection arthroplasty involves excision of the femoral head.**

- **Mold or cup arthroplasty involves resurfacing of the articular surface of the femoral head with a prosthetic device.**

- **Resurfacing arthroplasty involves a cup-type arthroplasty on the femoral side with a metal-on-metal acetabular component.**

- **Unipolar prosthetic arthroplasty involves replacement of the femoral head with a nonmobile bearing head.**

- **Bipolar arthroplasty involves replacing the femoral head with a mobile bearing component.**

The trapdoor procedure involves open excision of the necrotic bone by elevation of the cartilage and cancellous grafting.
Limited femoral resurfacing for young patients with intact acetabular cartilage and a collapsed femoral head is a valuable alternative to total hip replacement. Total hip replacement, with a femoral and an acetabular component, currently is the end result of the disease.

**Postoperative Details**

- Core decompression - Non-weightbearing ambulation for 6-12 weeks, then gradual resumption of normal activities as tolerated
- Cancellous bone grafting - Similar to core decompression
- Cortical bone grafting - No weight bearing for 6 weeks, with progressive weight bearing to 6 months
- Trapdoor - Twenty percent weight bearing for 6 weeks, 50% weight bearing to 10 weeks, then progress to full weight bearing
- Arthrodesis - No weight bearing, with full weight bearing initiated at 3 months
- Osteotomy - Protected weight bearing for 6 weeks with gradual progression
- Limited femoral resurfacing - Fifty percent weight bearing for 6 weeks, then weight bearing as tolerated
- Resurfacing arthroplasty - Rehabilitation similar to total hip arthroplasty
- Arthroplasty - Weight bearing as tolerated immediately following surgery, depending on surgeon preference

**Follow-up**

- Core decompression: Success rates are better than those with conservative treatment, with approximately 70% success in stages before radiographic collapse and limited morbidity. Core decompression has been shown to be a highly cost-effective alternative when a total hip replacement is delayed by 5 years or more.
- Cancellous grafting: No statistical evidence exists of superiority over core decompression alone.
- Cortical grafting (avascular): No evidence exists of superiority over core decompression.
- Vascularized fibular grafting: The procedure is technically difficult with increased morbidity and has questionable benefit compared with core decompression.
- Tantalum implants: Recent retrieval studies have shown little bone ingrowth, insufficient mechanical support of subchondral bone, and a significant rate of femoral head collapse.
- Trapdoor: Indicated more in stage III disease, in which above procedures are unsuccessful; 83% good or excellent results were demonstrated in 1 study.
- Osteotomy: This procedure is technically very difficult; use in cases in which total hip replacement is not advisable, understanding that future total hip replacement is technically more difficult.
- Cup arthroplasty, unipolar arthroplasty, and bipolar arthroplasty: Success rates are poor; disease appears to affect both sides of the hip joint.
- Limited femoral resurfacing: Newer designs have increased the longevity of the procedure to greater than 10 years. Therefore, limited femoral resurfacing is a valuable alternative to total hip replacement in young patients with osteonecrosis; however, some studies suggest poor results when compared with age-matched patients.
with osteoarthritis.

- **Total resurfacing arthroplasty**: Greater than 90% survivorship at greater than 3 years
- **Arthrodesis**: Results are poor in terms of achieving fusion and patient satisfaction.
- **Total hip replacement**: Early results were poor with early cement techniques, with failures up to 25% or higher. Recent studies have shown success rates at over 90% with current techniques, making it the treatment of choice following collapse or failure of less-invasive procedures.

### Complications

- **Core decompression**: Complications are minimal in the hands of experienced surgeons. The most severe complication is fracture, which can occur if core is drilled below the trochanteric ridge.
- **Bone grafting procedures**: The same complications as with core decompression, along with donor-site morbidity; peroneal sensory neuropathy, contractures of the flexor hallucis longus, deep venous thrombosis, and ankle pain with ambulation have been noted in vascularized fibular graft procedures.
- **Trapdoor**: Limited complications are reported aside from deep venous thrombosis.
- **Osteotomies**: Complications include nonunion and malunion, along with those stated above.
- **Limited femoral resurfacing**: Cases of loosening and acetabular wear have been reported but complications are minimal.
- **Total resurfacing arthroplasty**: Femoral neck fracture is the most common and critical complication; patient selection is key.
- **Total hip replacement**: Infection, peroneal nerve palsy, deep venous thrombosis, intraoperative fracture, and postoperative dislocation are noted; risk-benefit ratio strongly reflects success of procedure.

### Outcome and Prognosis

The success rate in patients not treated by arthroplasty in stage 0 or I approaches 90% in some series. Once femoral head collapse occurs, these treatments offer limited benefit. Procedures such as the trapdoor procedure potentially may improve results in stage II and III, but presently, total hip replacement remains the treatment of choice once collapse has occurred. If not treated, 80% of femoral heads collapse within 4 years of diagnosis. Location and extent of the necrotic lesion appear to be good indicators of collapse of the femoral head.

### Future and Controversies

The natural history of atraumatic osteonecrosis is still not well understood. Different etiologies of the disease often have different clinical courses. Steroid-induced disease has the worst prognosis, and most cases progress to collapse of the femoral head. Future studies hopefully will focus on the natural history of the disease; surgical procedures of limited morbidity to prevent collapse in the early stages; and procedures for use following collapse but before development of arthritis, short of total hip replacement.

Prostheses with novel bearing surfaces (ie, metal-on-metal, ceramic-on-ceramic) are being investigated, to increase the success rate for total hip replacements in patients with osteonecrosis.

### Multimedia

http://emedicine.medscape.com/article/1247804-print
Media file 1: Osteonecrosis, hip. Anteroposterior radiograph showing Ficat stage III disease.

Media file 2: MRI showing osteonecrosis of right hip, normal left hip.
Media file 3: Bone scan showing osteonecrosis of right hip.
Media file 4: Osteonecrosis, hip. Anteroposterior radiograph core biopsy.
Media file 5: Osteonecrosis, hip. A radiograph of a limited femoral resurfacing performed for a collapsed femoral head with damaged femoral head cartilage and intact acetabular cartilage.

References


**Keywords**

- hip osteonecrosis
- aseptic necrosis
- avascular necrosis
- osteonecrosis of the femoral head
- ischemic necrosis
- protein C deficiency
- protein S deficiency
- sickle cell anemia

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