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OSTEONECROSIS

Mohammed Ayed M Alshammari[1], Mohammad Talal Melibary[2], Ali Ibrahim Alresasy[3], Mohammed Ahmed Almutawah[3], Omer Siraj Brinji[4], Abdullah Essam Alomair[5], Yahya Waleed Al-Arfaj[5], Meshal Yahya Altowairqi[6]

[1] King Abdullah Medical Complex
[2] East Jeddah Hospital
[3] Imam Abdulrahman Bin Faisal University
[4] King Saud Bin Abdulaziz University for Health Sciences – Jeddah
[5] King Faisal University
[6] Imam Muhammad Ibn Saud Islamic University

Abstract:

Introduction: *decreased blood flow to the head of femur is a degenerative process leading to cell death and eventually to osteonecrosis. It occurs mostly in people aged 20-40 and is a common presentation for orthopedic surgery consultation. The surgeons usually decide management plan on a case basis, and depending on the age of the patient, gender, severity of symptoms, stage of the disease, and the presence of other comorbidities.*

Methodology: *We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 1985, through February 2017. The following search terms were used: osteonecrosis, femoral head necrosis, orthopedic surgery of hip, surgical management of hip necrosis*

Aim: *In this review, we aim to study the pathophysiology behind osteonecrosis of the hip and understand its surgical management.*

Conclusion: *To diagnose femoral head osteonecrosis, clinical and radiologic findings are evaluated. There is no specific treatment which is proven to decrease the progression of the disease and interfere with its natural progression. All present medical and surgical interventions aim at symptomatic relief and prevention of permanent damage. Future studies are needed to study different surgical approaches and provide evidence on which to use in each subpopulation.*

Keywords: *osteonecrosis, femoral head necrosis, orthopedic surgery of hip, surgical management of hip necrosis*

Corresponding author:

Mohammed Ayed M Alshammari,
King Abdullah Medical Complex
dr.alshammari91@gmail.com
00966562599919

QR code

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INTRODUCTION:

When blood flow in the head of the femur decreases, this will lead to a degenerative process that consists of the death of the cells, bone fractures, and articular surface collapse. This whole degenerative process will eventually end up with the development of femoral head osteonecrosis **[1]**. Femoral head osteonecrosis generally occurs in young, and relatively active individuals aged between twenty and forty years. It usually progresses gradually and eventually leads to significant dysfunctions in joint movements. Every year, up to 30,000 patients are diagnosed with femoral head osteonecrosis in the United States, causing about ten percent of the total number of hip arthroplasty surgeries. It is relatively rare for femoral head osteonecrosis to occur spontaneously. However, when this happens, most patients will progress to a severe disease with very high recurrence rates that reach 85% of patients **[2]**. Universally, the community of orthopedics has not yet put solid guidelines for the management and treatment of femoral head osteonecrosis. However, physicians usually decide management plan on a case basis, and depending on the age of the patient, gender, severity of symptoms, stage of the disease, and the presence of other comorbidities. This is because there is no solid evidence to support a treatment plan over another one, which make management of these patients relatively hard. The most important goal in managing these patients is to stop the progress of the disease and prevent the development of a severe disease that will require hip joint surgery. Early proper intervention is essential to protect the joint and preserve movements **[3]**.

METHODOLOGY:

•Data Sources and Search terms

We conducted this review using a comprehensive search of MEDLINE, PubMed, and EMBASE, January 1985, through February 2017. The following search terms were used: osteonecrosis, femoral head necrosis, orthopedic surgery of hip, surgical management of hip necrosis

•Data Extraction

Two reviewers have independently reviewed the studies, abstracted data, and disagreements were resolved by consensus. Studies were evaluated for quality and a review protocol was followed throughout.

The study was approved by the ethical board of King Abdulaziz University Hospital.

Pathogenesis

Several factors have been associated with the development of femoral head osteonecrosis. These factors are grouped into traumatic and atraumatic. However, the exact etiologies and mechanisms are not yet well-understood. In the United States, alcohol can attribute to up to 40% of femoral osteonecrosis cases. Other significant risk factors include corticosteroids treatment (which is responsible for about 30% of femoral head osteonecrosis cases), and about 30% of cases are idiopathic **[4]**.

Previous research has suggested that femoral head osteonecrosis is usually a result of genetic factors, metabolic factors, and environmental factors, all together. The presence of a vascular comorbidity could also lead to the development of the disease by altering blood flow through vessels, changing intraosseous pressure, and leading to mechanical damage. All these factors work together to produce hypoxemia in the bone which will lead to ischemia and infarction, and eventually bone necrosis. Direct trauma to the vessels, occlusion of the vessels, cellular toxicity, and dysfunctional stem cells differentiation, will all lead to the development of ischemia **[5]**.

Occlusion of the vessels happens following several mechanisms. These include, the intake of glucocorticoids in high doses. This is the case in many systemic and autoimmune diseases like systemic lupus, Crohn's disease, rheumatoid arthritis, along with other diseases. Alcohol intake has also been associated with lipids dysfunctions which will lead to emboli going to the arteries over the body (including bones) causing their occlusion **[6]**. Fat emboli has also been associated with vascular occlusion and femoral head osteonecrosis. Venous stasis, and adipocyte hypertrophy have also been suggested to be involved in the disease. Diseases that cause coagulopathies have also been associated with femoral head osteonecrosis, as these diseases with increase the risk of thrombi and emboli formation. Examples of these diseases include antiphospholipid antibodies, thrombophilia, fibrinolysis dysfunctions, along with other disease that have been linked with coagulopathies. Sickling of RBCs and hyperplasia of bone marrow cells are both observed in sickle cell disease, and Gaucher's disease, and both lead to higher risk in vascular occlusion, and femoral head osteonecrosis. Increased pressure observed in decompression sickness can also cause the formation of bubbles that consist of nitrogen. These bubbles can accumulate and occlude arterioles and arteries leading to ischemia and necrosis. Nitrogen bubbles have also been seen to cause higher levels of plasminogen activator inhibitors in the plasma, this will cause more coagulation **[7]**.

When trauma occurs to a bone, the resulting fracture

will lead to dislocation. This dislocation will affect the blood supply of the bone especially when the fracture occurs in the subcapital area of the femur. This specific type of fractures affects vascular anastomoses which originate from the ligamentum teres artery, and the circumflex artery, leading to insufficient blood flow to the femoral head.
One last important cause of femoral heal osteonecrosis is radiotherapy, chemotherapy, or oxidation that will all lead to damage of cells. This damage occurs due to the decrease of differentiation of osteocytes and the diversion of mesenchymal cells toward different cell lineages (like adipocytes) **[5]**.

Diagnosis
It is extremely important to early diagnose and manage femoral head osteonecrosis, as this has been found to be associated with significantly improved outcomes. Currently, physicians use radiography modalities, functional evaluation of bone, scintigraphy modalities, magnetic resonance imaging (MRI), histological studies, and computer-assisted tomography.

What makes early diagnosis of femoral head osteonecrosis challenging sometimes, is being asymptomatic especially in early stages. However, some patients will still suffer from pain in the groin. This pain can radiate to the buttock or the knee.

Physical examination in symptomatic osteonecrosis cases will show limited movement at the hip joint, and pain on passive internal rotation. A full, thorough detailed history is very important as it will aid in identifying possible risk factors and etiologies of the disease **[4]**.

A presentation with hips pain, with any risk factor should draw attention to a possible femoral head osteonecrosis case, even if plain radiography is negative. This is before in early stages of the disease, plain radiographs are usually normal and are not sensitive enough to detect necrosis. Moreover, patients with a history of a prior femoral head osteonecrosis should be strictly examined and watched for the development of a bilateral osteonecrosis. In fact, this population have a 70% risk of developing bilateral femoral head osteonecrosis **[8]**.

When diagnosing and staging femoral head osteonecrosis, there are two common classifications that are used by most physicians. These two classifications are the Steinberg University of Pennsylvania system and the Ficat and Arlet system **[9]**.
The Ficat classification has four stages, which are determined according to the radiographic findings. For example, stage one means that radiographic findings are normal, stage two means that radiographs show cystic or osteosclerotic regions (bone-remodeling), but normal contour of the femoral head. On the other hand, stage three means that radiography shows flattening of the femoral head and/or subchondral collapse, and stage four means narrowing of the space along with degeneration of the acetabulum, and cartilage destruction. Later, stage 0 was added to the classification by Hungerford who described it as having a 'silent hip' with no clinical or radiographic findings but can be suggested if the patient was already diagnosed with an osteonecrosis in the other femoral head. In these cases, histological studies of the bone, and the pressure of the bone marrow will show abnormal results **[8]**.

Despite being well established, the Ficat classification has one major limitation, which is its full dependency on imaging findings, without considering the size of the lesion. This makes it hard to stage and measure the progression of the osteonecrosis **[9]**.

Therefore, the Steinberg system was developed to expand the Ficat system and make it more general. In the Steinberg system, there are six different stages. It also classifies the disease according to severity into mild (with the involvement of less than 15% of the femoral head joint surface on radiography), moderate (with the involvement of 15% to 30% of the femoral head joint surface on radiography) and severe (with the involvement of more than 30% of the femoral head joint surface on radiography) **[9]**.
The Association Research Circulation Osseous (ARCO) has also recently suggested a much newer grouping system that depends on all radiographic, magnetic resonance imaging, histology, and bone scan findings.

Despite the presence of all these classifications, diagnosis of femoral head osteonecrosis continues to be challenging and difficult for physicians. Generally, the diagnosis of femoral head osteonecrosis depends on plain antero-posterior radiograph of the hip in the frog-leg lateral position. This plain radiograph will assess areas involved, and is then followed by magnetic resonance imaging **[10]**. On a plain radiograph, the first change to see in the femoral head is cystic and/or sclerotic. The frog-leg lateral position is essential as some lesions may not appear early in other positions. Crescent sign could be present and indicates cartilage involvement. The femoral head could also be flattened on radiographs **[5]**.

Surgical Management

No solid evidence is present in the literature to support the use of a certain surgical approach for the treatment of femoral head osteonecrosis in adults. Most members of the American Association of Hip and Knee Surgeons reported in a recent survey that they believe that total hip replacement is the most common and efficient intervention in cases of collapsed femoral head osteonecrosis. However, in prior stages, they said they believed that core decompression is the preferred modality of treatment **[11]**.

Conservative management, vascularized bone grafts, non-vascularized bone grafts, osteotomy, hemi-arthroplasty, and arthrodesis are all other possible treatment modalities but are less commonly used by surgeons. Generally, femoral head osteonecrosis affects younger individuals, making it important to provide any procedure that will lead to pain relief and maintain function **[12]**.

Surgical approaches to treat femoral head osteonecrosis are usually divided into two major categories: procedures that spares the femoral head (FHSP), and procedures that replaces the femoral head (FHRP). Generally, femoral head sparing procedures (FHSP) are done in patients who have a pre-collapse osteonecrosis and minimal symptoms, while femoral head (FHRP) replacement procedures are performed in patients who suffer from a collapsed osteonecrosis with severe symptoms **[12]**.

FH sparing procedures:

The goal of femoral head sparing procedures is to preserve the femoral head. These procedures include core decompression, which can be combined with grafting procedures, biologic agents, and/or rotational osteotomies. However, these procedures are not efficient enough, therefore they do not have a role in managing collapse stages of the disease **[13]**.

Core decompression:

Femoral head core decompression is considered to be one of the most common procedures used in early stages of femoral head osteonecrosis. The goal of femoral head core decompression is to restore blood flow and lead to decreased pain **[14]**.

Femoral head core decompression has been shown to cause significant delay in the progression of femoral head osteonecrosis. However, it is not established yet whether it has a role in reconstruction of necrotic areas **[14]**.

Bone grafting procedures:

Bone grafts (non-vascularized type) can be obtained from several sources, and have been used in filling necrotic areas in the femoral head in cases of osteonecrosis. Graft filling occurs through the tract made by core decompression.

On the other hand, vascularized types of bone grafts have several advantages over the non-vascularized type. However, no solid evidence is yet present about its efficacy and safety **[15]**.

Tantalum implants:

Another option is porous tantalum implant that is usually used with core decompression of the femoral head. This approach has several advantages including mechanical support of the femoral head, and the decreased risk of developing infections. In a previous study, Veillete et al.**[16]** found that the overall survival following core decompression with the insertion of a porous tantalum implant was 91.8% at two years and 68.1% at four years. Despite showing good survival outcomes, surgeons still have their concerns on this technique. Therefore, more studies with longer follow up periods should be performed to establish stronger evidence on this approach.

Biological agents:

Recently, the use of biological agents has been raising with promising results. The use of biologic agents in femoral head osteonecrosis specifically has been studied. These agents are suggested to improve osteogenesis and core decompression, and have been found to show better efficacy in larger lesions **[17]**.

Osteotomies:

There are two main types of osteotomies: rotational transtrochanteric and angular intertrochanteric. Both types are usually performed in femoral head osteonecrosis to remove weight from the areas that show necrotic tissues **[18]**.

In 1972, Sugioka was the first to introduce the use of rotational transtrochanteric osteotomy in treating femoral head osteonecrosis. This procedure aimed initially to rotate necrotic areas of the femur so that they become out of weight bearing areas in the hip. When it was first tried, this approach showed promising results with a success rate over 80% for up to 16 years. However, due to the difficulty of this procedure and the need of advanced techniques, these results have not been later reproduced **[19]**.

In another study, Hisatome et al.**[18]** analyzed results from 21 patients who underwent Sugioka's transtrochanteric anterior rotational osteotomy for treatment of femoral head osteonecrosis after six

years of the procedure. They found that despite prevention of collapse of a new region, the collapse of the already damaged regions still progressed.

This approach generally showed promising results, but is still not commonly used due to several limitations. It is considered a good option in young patients and when is performed by an expert surgeon. The ideal way to do it is with an angle less than 200 and with cessation of steroids **[19]**.

Hemi-resurfacing arthroplasty and hemipolar/bipolar hip replacement:

In patients with a joint that is still preserved with minimal damage to the joint cartilage, hemi-resurfacing arthroplasty is considered to be a good treatment approach. More specifically, this approach is used in patients who have a Ficat III, early stage Ficat IV osteonecrosis. It can also be used in cases of fibula graft failure **[20]**.

When applied on the proper population, and by expert surgeons, hemi-resurfacing arthroplasty can potentially maintain movement and function of the patient. However, pain relief after the procedure may still be suboptimal. This approach can lead to some distortion of the bone anatomy, but it preserves the bone itself, and leads to the accumulation of only minimal debris **[20]**.

THA:

Total hip arthroplasty is usually only applied on older patients who have late severe femoral head osteonecrosis and severe arthritis. In fact, total hip arthroplasty is the only treatment modality for femoral head osteonecrosis that has been proven to decrease pain and maintain movements **[21]**.

CONCLUSION:

Femoral head osteonecrosis is considered to be common and severe diseases that significantly affect patients leading to severe deniability. Early diagnosis of the disease is essential to properly manage and treat it before it progresses into a more severe disease with permanent damage. To properly diagnose femoral head osteonecrosis, clinical and radiologic findings need to be evaluated. Until now, no specific treatment has been proven to decrease the progression of the disease and interfere with its natural progression. All present medical and surgical interventions aim at symptomatic relief and prevention of permanent damage. Future studies are needed to study different surgical approaches and provide evidence on which to use in each subpopulation.

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