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THE FREQUENCY OF FEMOROACETABULAR IMPINGEMENT SYNDROME IN YOUNG PATIENTS COMPLAINING FROM HIP OR GROIN PAIN

RESIDENCY THESIS

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ABBREVATIONS

FAI	: FEMOROACETABULAR IMPINGEMENT
ROM	: LIMITED RANGE OF MOTION
MRI	: MAGNETEC RESONANCE IMAGING
CT	: COMPUTED TOMOGRAPHY
OA	: OSTEOARTHRITIS
AP	: ANTEROPOSTERIOR
NSAIDs	: NONSTEROIDAL ANTI-INFLAMMATORY DRUGS
RA	: RHEUMATOID ARTHRITIS
SI	: SACROILITIS
AS	: ANKYLOSING SPONDYLITIS

CONTENTS

ÖZET

Amaç : Bu çalışmanın amacı , kalça ağrısı nedeniyle kalça grafisi çekilmesi istemi ile kliniğimize başvuran genc hastalarda , femoroacetabular impingement sıklığının araştırılmasıydı.

Materyal ve Yöntem : 200 kalça grafisi üç ay süre ile toplandı ve prospektif olarak analiz edildi , kalça ağrısı olan her hastaya anteroposterior kalça grafisi çektirildi ve radyolojic belirtilerine göre femoroacetabular impingement sendrumu araştırıldı.

Sonuç : 190 hasta , çalışma kriterlerine uygun olarak çalışmaya dahil edildi , 20 hastada FAİ bulundu (10.5%) , bunlardan, 15 hastada cam tipi femoroacetabular impingement belirtileri bulundu(7.9%) , 4 hastada picer tipi femoroacetabular impingement belirtileri bulundu(2.1%) , ve 1 hastada mixed femoroacetabular impingement belirtileri bulundu .

Degenerative artrit femoroacetabular impingemente sekonder olarak 6 vakada bulundu(çalışma grubunun 3.1% ü ; femoroacetabular impingement hastalarının 30% u).

Ayrıca 16 vakada osteoartrit , 11 vakada inflamatory artrit , 8 vakada doğumsal kalça displazisi , ve bir vakada aneurysmal kemik kisti bulundu.

Sonuç olarak femoroacetabular impingement klinik ve radyolojic olarak 2 tipe ayrılır – pincer ve cam – kalça ağrısı olan genc ve aktif hastaları tutma eğilimi gösterir. Osteoartritin genc yaşlarda gelişimi bu durumun ciddiyetini gösterir. Femoroacetabular impingement belirtileri ortaya çıktığında,ileri klinik ve radyolojik çalışma gerekmektedir.

SUMMARY

Purpose : The purpose of our study was to evaluate the plain radiograph in the identification of femoral & acetabular pathologies in young patients suffering from hip or groin pain to assess the frequency of feomoroacetabular impingement syndrome in these patients.

Material & Method : A total of 200 plain radiographs of the hip were collected over a three month period and analysed prospectively, a history of hip or groin pain was present in all cases, an anteroposterior view of plain pelvic radiograph has been taken for each patient and the radiological signs for the femoroacetabular impingement syndrome has been evaluated.

Results : 190 patients fulfilled the study criteria and were eventually included in the study. Twenty patients were found to have FAI (10.5%). Of these patients 15 had signs of cam type femoroacetaular impingement (7.9%), 4 had signs of pincer type impingement (2.1%), and 1 (0.5%) had signs of mixed femoroacetabular impingement on radiographs. Fourteen of the cases were males and only 1 case was female. Degenerativbe arthririts secondary to FAI were seen in 6 cases (3.1 % of total study group; 30 % of patients with FAI).

Findings other than FAI were osteoarthrirtis (16 cases), inflammatory arthritis (11 cases), congenital hip dysplasia (8 cases), and aneurysmal bone cyst (1 case).

Conclusion : In conclusion, two main forms of femoroacetabular impingement—pincer and cam—occur in young active individuals presenting with hip pain and the development of osteoarthritis at an early age makes this condition essential. Further clinical and radiological work-up is necessary when findings suggestive of FAI are present.

INTRODUCTION

Femoroacetabular impingement, previously termed acetabular rim syndrome, is a major factor in early development of osteoarthritis of the hip (1,7).This syndrome is caused by abnormal contact between the osseous protrusions of the acetabulum and the femur during hip joint movement (1).In patients with femoroacetabular impingement, repetitive microtrauma from the osseous impingement leads to recurring irritation, degenerative changes of the labrum, and ultimately irreversible cartilaginous damage (1,2,4,5,8,11).

Femoroacetabular impingement tends to involve young, active patients and can be debilitating (4,9,10).Femoroacetabular impingement is often bilateral, but may be symptomatic on only one side (1).Femoroacetabular impingement is diagnosed and classified into two types, pincer and cam, by the clinical and radiologic presentation (8).However, most cases of femoroacetabular impingement are a combination of the two subtypes.

Pincer impingement is caused by acetabular overcoverage with normal femoral head sphericity (1,2,4,8,9).The pincer effect is the linear contact between a normal neck and an overcovering acetabular rim, which can lead to labral damage (2,8,9).Pincer impingement is more common in middle-aged women with abnormalities of acetabular morphology (4,5,8,10,11).

Cam impingement arises from a prominence of the femur that leads to an abnormal, aspherical shape of the femoral head-neck junction (1,4,8).This terminology arises from the cam, which is the projecting part of a rotating wheel or shaft that strikes a lever at one or more points on its circular path. The asphericity or abnormal head-neck offset in cam impingement is thought to result from subclinical slipped capital femoral epiphysis or a growth disturbance of the proximal femur (9). The cam effect leads to abrasion and chondropathy with only partial involvement of the labrum (2).Cam impingement is more common in young males with underlying abnormalities of the femoral head morphology (4,5,8,10,11).

The purpose of our study was to evaluate the plain radiograph in the identification of femoral and acetabular pathologies in young patients suffering from hip or groin pain to assess the frequency of feomoroacetabular impingement syndrome in these patients.

EMBRYOLOGY (22)

Development of joints

Joints begin to develop with the appearance of the **interzonal mesenchyme** during the sixth week, and by the end of the eighth week, they resemble adult joints. Joints are classified as fibrous joints, cartilaginous joints, and synovial joints. Joints with little or no movement are classified according to the type of material holding the bones together, for example, the bones involved in fibrous joints are joined by fibrous tissue.

Fibrous Joints

During the development of fibrous joints, the **interzonal mesenchyme** between the developing bones differentiates into dense fibrous tissue ,for example, the sutures of the cranium are fibrous joints.

Cartilaginous Joints

During the development of cartilaginous joints, the interzonal mesenchyme between the developing bones differentiates into **hyaline cartilage** (e.g., the costochondral joints) or **fibrocartilage** (e.g., the pubic symphysis) .

Synovial Joints

During the development of synovial joints (e.g., the knee joint), the interzonal mesenchyme between the developing bones differentiates as follows: Peripherally it forms the capsular and other ligaments. Centrally it disappears, and the resulting space becomes the **joint cavity** or synovial cavity. Where it lines the joint capsule and articular surfaces, it forms the **synovial membrane** (which secretes synovial fluid), a part of the joint capsule (fibrous capsule lined with synovial membrane) Probably as a result of joint movements, the mesenchymal cells subsequently disappear from the surfaces of the articular cartilages. An abnormal intrauterine environment restricting embryonic and fetal movements may interfere with limb development and cause joint fixation.

Development of the appendicular skeleton:

The appendicular skeleton consists of the pectoral and pelvic girdles and the limb bones. Mesenchymal bones form during the fifth week as condensations of mesenchyme appear in the limb buds . During the sixth week, the **mesenchymal bone models** in the limbs undergo chondrification to form **hyaline cartilage bone models** . The clavicle initially develops by intramembranous ossification, and it later forms growth cartilages at both ends. The models of the pectoral girdle and upper limb bones appear slightly before those of the pelvic girdle and lower limb bones; the bone models appear in a proximodistal sequence. Patterning in the developing limbs is regulated by homeobox-containing (*Hox*) *genes* .

Ossification begins in the long bones by the eighth week and initially occurs in the diaphyses of the bones from **primary ossification centers** . By 12 weeks, primary ossification centers have appeared in nearly all bones of the limbs . The clavicles begin to ossify before any other bones in the body. The femora are the next bones to show traces of ossification. The first indication of the primary center of ossification in the cartilaginous model of a long bone is visible near the center of the future shaft (diaphysis). Primary centers appear at different times in different bones, but most of them appear between the 7th and 12th weeks. Virtually all primary centers of ossification are present at birth.

The **secondary ossification centers** of the bones at the knee are the first to appear in utero. The secondary centers for the distal end of the femur and the proximal end of the tibia usually appear during the last month of intrauterine life. Consequently, these secondary centers are usually present at birth; however, most secondary centers of ossification appear after birth. The part of a bone ossified from a secondary center is the **epiphysis**. The bone formed from the primary center in the diaphysis does not fuse with that formed from the secondary centers in the epiphyses until the bone grows to its adult length. This delay enables lengthening of the bone to continue until the final size is reached. During bone growth, a plate of cartilage known as the **epiphysial cartilage plate** intervenes between the diaphysis and the epiphysis . The epiphysial plate is eventually replaced by bone development on each of its two sides, diaphysial and epiphysial. When this occurs, growth of the bone ceases.

THE ANATOMY OF THE HIP JOINT(15 – 21)

Articulation

The hip joint is a synovial joint formed by the articulation of the rounded head of the femur and the cup-like acetabulum of the pelvis.It forms the primary connection between the bones of the lower limb and the axial skeleton of the trunk and pelvis. Both joint surfaces are covered with a strong but lubricated layer called articular hyaline cartilage.The cuplike acetabulum forms at the union of three pelvic bones — the ilium, pubis, and ischium.The Y-shaped growth plate that separates them, the triradiate cartilage, is fused definitively at ages 14-16. It is a special type of spheroidal or ball and socket joint where the roughly spherical femoral head is largely contained within the acetabulum and has an average radius of curvature of 2.5 cm. The acetabulum grasps almost half the femoral ball, a grip augmented by a ring-shaped fibrocartilaginous lip, the acetabular labrum, which extends the joint beyond the equator. The head of the femur is attached to the shaft by a thin neck region that is often prone to fracture in the elderly, which is mainly due to the degenerative effects of osteoporosis.

The acetabulum is oriented inferiorly, laterally and anteriorly:

- The magnitude of **inferior orientation** can be assessed using a line connecting the lateral rim of acetabulum and center of femoral head. This line forms an angle with vertical known as center edge angle or angle of Wiberg an angle which should not be less than 10° 1-4 years of age, and within the range 15-20° at 5 years of age.
- The **transverse angle** can be determined by measuring the angle between a line passing from the superior to the inferior acetabular rim and the horizontal plane; an angle which normally measures 51° at birth and 40° in adults, and which affects the acetabular lateral coverage of the femoral head and several other parameters.

The magnitude of **anterior orientation**, referred as angle of acetabular anteversion, is the angle between the axis of the femoral neck and the axis of the femoral condyles. It affects the internal or external rotation of the leg ("toeing-in" or ‘toing out‘ gait). A normal angle is approximately 12°; an increased angle (toeing-in) is called coxa anteverta, and a decreased angle (toeing-out) coxa retroverta.

Capsule

The capsule attaches to the hip bone outside the acetabular lip which thus projects into the capsular space. On the femoral side, the distance between the head's cartilaginous rim and the capsular attachment at the base of the neck is constant, which leaves a wider extracapsular part of the neck at the back than at the front. The strong but loose fibrous capsule of the hip joint permits the hip joint to have the second largest range of movement (second only to the shoulder) and yet support the weight of the body, arms and head.

The capsule has two sets of fibers: longitudinal and circular.

- The circular fibers form a collar around the femoral neck called the zona orbicularis.
- The longitudinal retinacular fibers travel along the neck and carry blood vessels

Ligaments

The hip joint is reinforced by five ligaments, of which four are extracapsular and one intracapsular.

The **extracapsular** ligaments are the iliofemoral, ischiofemoral, and pubofemoral ligaments,attached to the bones of the pelvis (the ilium, pubis, and ischium respectively). All three strengthen the capsule and prevent an excessive range of movement in the joint. Of these, the Y-shaped and twisted iliofemoral ligament is the strongest ligament in the human body. In the upright position, it prevents the trunk from falling backward without the need for muscular activity. In the sitting position, it becomes relaxed, thus permitting the pelvis to tilt backward into its sitting position. The ischiofemoral ligament prevents medial rotation while the pubofemoral ligament restricts abduction in the hip joint. The zona orbicularis, which lies like a collar around the most narrow part of the femoral neck, is covered by the other ligaments which partly radiates into it. The zona orbicularis acts like a buttonhole on the femoral head and assists in maintaining the contact in the joint.

The **intracapsular** ligament, the ligamentum teres, is attached to a depression in the acetabulum (the acetabular notch) and a depression on the femoral head (the fovea of the head). It is only stretched when the hip is dislocated, and may then prevent further displacement. It is not that important as a ligament but can often be vitally important as a conduit of a small artery to the head of the femur. This arterial branch is not present in everyone but can become the only blood supply to the bone in the head of the femur when the neck of the femur is fractured or disrupted by injury in childhood.

Blood and nerve supply

The hip joint is supplied with blood from the medial circumflex femoral and lateral circumflex femoral arteries, which are both usually branches of the deep artery of the thigh,(profunda femoris), but there are numerous variations and one or both may also arise directly from the femoral artery. There is also a small contribution from a small artery in the ligament of the head of the femur which is a branch of the posterior division of the obturator artery, which becomes important to avoid avascular necrosis of the head of the femur when the blood supply from the medial and lateral circumflex arteries are disrupted (e.g. through fracture of the neck of the femur along their course).

The hip has two anatomically important anastomoses, the cruciate and the trochanteric anastomoses, the latter of which provides most of the blood to the head of the femur. These anastomoses exist between the femoral artery or profunda femoris and the gluteal vessels.

The hip joint is supplied by a number of nerves (proprioception, nociception, etc...) including the femoral nerve, the obturator nerve, superior gluteal nerve, and the nerve to quadratus femoris.

Muscles and Movements

The hip muscles act on three mutually perpendicular main axes, all of which pass through the center of the femoral head, resulting in three degrees of freedom and three pair of principal directions: Flexion and extension around a transverse axis (left-right); lateral rotation and medial rotation around a longitudinal axis (along the thigh); and abduction and adduction around a sagittal axis (forward-backward) ; and a combination of these movements (i.e. circumduction, a compound movement in which the leg describes the surface of an irregular cone). It should be noted that some of the hip muscles also act on either the vertebral joints or the knee joint, that with their extensive areas of origin and/or insertion, different part of individual muscles participate in very different movements, and that the range of movement varies with the position of the hip joint. Additionally, the inferior and superior gemelli may be termed *triceps coxae* together with the obturator internus, and their function simply is to assist the latter muscle.

The movements of the hip joint is thus performed by a series of muscles which are here presented in order of importance.with the range of motion from the neutral zero-degree position indicated:

- **Lateral** or **external rotation** (30° with the hip extended, 50° with the hip flexed): gluteus maximus; qadratus femoris; obturator internus; dorsal fibers of gluteus medius and minimus; iliopsoas (including psoas major from the vertebral column); obturator externus; adductor magnus, longus, brevis, and minimus; piriformis; and sartorius.
- **Medial** or **internal rotation** (40°): anterior fibers of gluteus medius and minimus,tenser fascia lata; the part of adductor magnus inserted into the adductor tubercle; and, with the leg abducted also the pectineus.
- **Extension** or **retroversion** (20°): gluteus maximus (if put out of action, active standing from a sitting position is not possible, but standing and walking on a flat surface is); dorsal fibers of gluteus medius and minimus; adductor magnus; and piriformis. Additionally, the following thigh muscles extend the hip: semimembranosus, semitendinosus, and long head of biceps femoris.
- **Flexion** or **anteversion** (140°): iliopsoas (with psoas major from vertebral column). Tensor fascia latae, pectineus, adductor longus, adductor brevis, and gracilis. Thigh muscles acting as hip flexors: rectus femoris and sartorius.
- **Abduction** (50° with hip extended, 80° with hip flexed): gluteus medius;tensor fascia latae; gluteus maximus with its attachment at the fascia lata; gluteus minimus; piriformis; and obturator internus.
- **Adduction** (30° with hip extended, 20° with hip flexed): adductor magnus with adductor minimus; adductor longus, adductor brevis, gluteus maximus with its attachment at the gluteal tuberosity; gracilis (extends to the tibia); pectineus, quadratus femoris; and obturator externus. Of the thigh muscles, semitendinosus is especially involved in hip adduction.

PATHOLOGIC ANATOMY

The condition occurs either as a result of morphological abnormality of the femoral head, so-called cam impingement, or the acetabular side, so-called pincer impingement. It is, however, important to point out that distinction between these is not always clear because abnormality of both the acetabulum and the femoral head-neck junction may be present in some patients (23).

Cam impingement is more common in young males with morphological abnormalities involving the femoral head (24)and (33). It is caused by the jamming of an abnormal femoral head with increasing radius into the acetabulum during forceful flexion. It has been associated with an elliptical femoral head, slipped capital femoral epiphysis, Legg-Calve-Perthes disease, adult osteonecrosis, and malunited femoral neck fractures. The shearing force results in an outside-in directed detachment of the acetabular rim cartilage anterosuperiorly from the labrum and subchondral bone, which in turn leads to avulsion of intact labrum.

A significant reduction in the mean femoral anteversion and mean head-neck offset in the anterior aspect of the femoral neck has been reported in these patients (34).Pincer impingement is a linear contact or abutment between the acetabular rim and the femoral head junction. The pathology is on the acetabular side, and the first damaged structure is the acetabular labrum. Chondral lesions in pincer impingement are usually limited and benign, but repeated impact on the labrum results in labral degeneration and intrasubstance ganglion formation or ossification of the acetabular rim, leading to progressive worsening of the overcoverage. It has been associated with acetabular retroversion, coxa profunda and protrusio acetabuli, iatrogenic overcorrection for retroversion in dysplastic hips, coxa vara, and os acetabuli. It is more common in middle-aged women with morphological abnormalities of the acetabulum (34) , (35),(24) and (33). Although the mentioned conditions may give rise to FAI, most cases are idiopathic.

OSTEOARTHRITIS OF THE HIP

PATHOPHYSIOLOGY

Biomechanical and biochemical forces are involved in cartilage destruction, which is at the core of osteoarthritis.Cytokines and growth factors are thought to play a role in the pathophysiology of the disorder. Interleukin-1 and tumor necrosis factor-b may function to activate enzymes involved in proteolytic digestion of cartilage (36).Growth factors such as tissue growth factor-b and insulin growth factor-1 may play a role in the body's attempts to repair cartilage through cartilage synthesis (37).

When catabolism exceeds cartilage synthesis, osteoarthritis develops. Collagenolytic enzymes are thought to contribute to the breakdown of cartilage. Collagenase 1 (matrix metalloproteinase-1 [MMP-1]) is a fibroblast collagenase, and collagenase 2 (MMP-8) is a neutrophil collagenase. Collagenase 3 (MMP-13) may be particularly important because of its highly potent collagenolytic activity (36).

Clinical Features and Diagnosis

History and Physical Examination

The typical patient with osteoarthritis is middle-aged or elderly and complains of pain in the knee, hip, hand or spine. Most often, the patient has pain and stiffness in and around the affected joint, along with some limitation of function (38-40).The symptoms are often insidious in onset.

Pain typically worsens with use of the affected joint and is alleviated with rest. Pain at rest or nocturnal pain is a feature of severe osteoarthritis. Morning stiffness lasting less than

30 minutes is common. (In contrast, morning stiffness in patients with active rheumatoid arthritis lasts longer than 45 minutes.)

Osteoarthritis usually does not affect the wrists, elbows or shoulders. However, a less common subtype of the disease is characterized by multiple joint involvement.

Patients with osteoarthritis of the hip may complain of problems with gait. Pain can vary greatly in site and nature, which sometimes makes early diagnosis difficult. The pain may be felt in the area of the buttock, groin, thigh or knee, and it can vary in character from a dull ache to a sharp, stabbing pain. Hip stiffness is common, particularly after inactivity, and can be a presenting feature. For example, a patient may mention that a stiff hip makes it difficult to put on socks. Early physical signs of osteoarthritis of the hip include restriction of internal rotation and abduction of the affected hip, with pain occurring at the end of the range of motion.

Patients with osteoarthritis of the knee often complain of instability or buckling, especially when they are descending stairs or stepping off curbs. Patients with osteoarthritis of the hands may have problems with manual dexterity, especially if the first carpometacarpal joint is involved.

Involvement of the apophyseal or facet joints of the lower cervical spine may cause neck symptoms, and involvement of the lumbar spine may cause pain in the lower back. Osteophytes of the vertebrae can narrow the foramina and compress nerve roots. As a result, patients may have radicular symptoms, including pain, weakness and numbness of the upper extremities.

The physical examination should include a careful assessment of the affected joints, surrounding soft tissue and bursal areas. Crepitus, which is felt on passive range of motion, is due to the irregularity of opposing cartilage surfaces and is a frequent sign of osteoarthritis of the knee. Periarticular disorders, such as anserine, infrapatellar or prepatellar bursitis, should be ruled out. These disorders can be mistaken for and inappropriately treated as osteoarthritis.

Patients with erosive osteoarthritis may have signs of inflammation in the interphalangeal joints of the hands. This inflammation can be mistaken for rheumatoid arthritis, which causes similar proximal interphalangeal joint swelling. However, osteoarthritis generally does not have an inflammatory component, except in advanced disease.The presence of a hot, erythematous, markedly swollen joint suggests a septic joint or a crystal arthropathy such as gout, pseudogout or hydroxyapatite arthritis.

Symptoms

Joint pain

Morning stiffness lasting less than 30 minutes

Joint instability or buckling

Loss of function

Signs

Bony enlargement at affected joints

Limitation of range of motion

Crepitus on motion

Pain with motion

Malalignment and/or joint deformity

Pattern of joint involvement*

Axial: cervical and lumbar spine

Peripheral: distal interphalangeal joint, proximal interphalangeal joint, first carpometacarpal joints, knees, hips.

CLASSIFICATION CRITERIA OF THE HIP OA.

Traditional format

Hip pain plus at least two of the following:

ESR of less than 20 mm per hour

Femoral or acetabular osteophytes on radiographs

Joint space narrowing on radiographs

Classification-tree format

Hip pain plus femoral or acetabular osteophytes on radiographs

or

Hip pain plus joint space narrowing on radiographs and an ESR of less than 20 mm per hour.

Radiographic Features and Laboratory Findings

Radiographs can usually confirm the diagnosis of osteoarthritis, although the findings are nonspecific. The cardinal radiographic features of the disease are a loss of joint space and the presence of new bone formation or osteophytes.The association between joint pain and the radiographic features of osteoarthritis is not constant, in that many joints with pathologic or radiographic evidence of this disease remain asymptomatic. Because bone demineralization is not a radiographic feature of osteoarthritis, its presence strongly suggests an inflammatory condition such as rheumatoid arthritis.

Most routine blood tests are normal in patients with uncomplicated osteoarthritis. Analysis of synovial fluid usually reveals a white blood cell count of less than 2,000 per mm^3 (2.0 3 10^9 per L).

Osteoarthritis secondary to a metabolic, genetic or other joint disorder should be suspected in the patient with widespread disease, a prominent inflammatory component, an unusual joint distribution or disease onset before 50 years of age. If the diagnosis of osteoarthritis is in doubt, consultation with a rheumatologist should be sought.

The American College of Rheumatology (ACR) has developed diagnostic criteria for osteoarthritis at various sites, including the hip (38).The knee *(39).*And the hand (40).

Treatment

Treatment of osteoarthritis should be individualized. Comorbid conditions such as cardiac disease, hypertension, peptic ulcer disease or renal disease must be considered, and the patient's needs and expectations should also be taken into account.

Nonpharmacologic Management

Patient Education. Arthritis self-help courses conducted by allied health professionals teach patients how to manage their disease. Participation in such courses has been associated with decreased pain and improved quality of life (41,43-45).

Local chapters of the Arthritis Foundation administer self-help courses for patients with osteoarthritis. Educational materials to help patients better understand and cope with osteoarthritis can also be obtained from the Arthritis Foundation

Regular patient contact has also been shown to be valuable in the management of osteoarthritis. One study found that monthly telephone communications with patients were cost-effective and were associated with good clinical outcomes (46).

Exercise. Patients are often concerned that joint use will "wear out" a damaged joint. However, the available evidence shows that regular low-impact exercise of osteoarthritic joints does not increase the development of osteoarthritis (47,48).

The goals of an exercise program are to maintain range of motion, muscle strength and general health. All patients with osteoarthritis of the knee should be taught quadriceps-strengthening exercises and should be encouraged to perform them every day.

Patients may also be referred to aerobic exercise programs such as fitness walking or swimming. Patients with osteoarthritis who participate in an aerobic exercise program have been shown to have improved aerobic capacity and 50-ft walking times, as well as decreased depression and anxiety, compared with patients who only perform range-of-motion exercises (49).

Assistive Devices. Many patients with osteoarthritis of the hip and knee are more comfortable wearing shoes with good shock-absorbing properties or orthoses.

The use of an appropriately selected cane can reduce hip loading by 20 to 30 percent(50). Attention must be given to the length of the cane and how it is to be used. The top of the cane's handle should reach the patient's proximal wrist crease when the patient is standing with arms at the side. The cane is usually held on the unaffected side of the body.

Patients with specific physical disabilities may benefit from physical and occupational therapy. The physical therapist can provide an individualized exercise program and teach the patient how to use therapeutic heat and massage. An occupational therapist can determine whether the patient needs assistive devices such as a raised toilet seat. In addition, special splints can be designed to stabilize or reduce inflammation of particular joints, such as the first carpometacarpal joint or the base of the thumb.

Weight Management. There is a longitudinal association between obesity and osteoarthritis of the knee in men and women, although obesity is a greater risk factor in women (51).Therefore, primary preventive strategies may include measures to avoid weight gain, or to achieve weight loss in overweight patients. It is not clear whether weight loss will improve symptoms in patients who are already experiencing symptoms of osteoarthritis of the knee (52).Further studies are needed to determine if weight loss has a role in the tertiary prevention of osteoarthritis.

Supplements. The lay media and books have widely proclaimed dietary supplements such as glucosamine sulfate and chondroitin sulfate to be "cures" for arthritis. Although small trials conducted in Europe and the United States showed some efficacy for these agents, (53,54). the trials were flawed in design and included few patients.

Randomized controlled trials are currently being conducted to determine whether glucosamine sulfate and chondroitin sulfate are safe, tolerated and effective in patients with osteoarthritis. At present, these supplements cannot be recommended for use in the treatment of osteoarthritis.

Pharmacologic Treatments

Simple Analgesics. A large number of medicines are prescribed for and consumed by patients with osteoarthritis, largely for the relief of pain. The recognition that pain in osteoarthritis is not necessarily due to inflammation has led to an increased awareness of the role of simple analgesics in the treatment of this disease.

The ACR guidelines emphasize the use of acetaminophen as first-line treatment for osteoarthritis of the hip and knee (41-45).One randomized, double-blind, crossover trial showed that, compared with placebo, acetaminophen in a dosage of 4 g per day significantly relieved pain and improved function in patients with osteoarthritis of the knee (55).

Opioid-containing analgesics, including codeine and propoxyphene (Darvon), can be used for short periods to treat exacerbations of pain. These agents are not recommended for prolonged use because they cause constipation and increase the risk of falling, particularly in the elderly.

Nonsteroidal Anti-inflammatory Drugs (NSAIDs). Trials comparing simple analgesics and NSAIDs found that acetaminophen alone can control pain in a substantial number of patients with osteoarthritis (56-58).In patients requiring NSAID therapy, concurrent use of acetaminophen may allow the NSAID dosage to be reduced, thereby limiting toxicity. In the individual patient, cost, dosing frequency and medication tolerance may influence NSAID selection.

Local Analgesics. Capsaicin (e.g., ArthriCare), a pepper-plant derivative, has been shown to be better than placebo in relieving the pain of osteoarthritis. One double-blind randomized, controlled trial showed that 0.025 percent capsaicin cream applied four times daily was effective in the management of pain caused by osteoarthritis of the knee, ankle, wrist and shoulder (59).The improvement in pain was measured by visual analog scales.

Intra-articular Corticosteroid Injections. Patients with a painful flare of osteoarthritis of the knee may benefit from intra-articular injection of a corticosteroid such as methylprednisolone (Medrol) or triamcinolone (Aristocort)(60,61).When a joint is painful and swollen, short-term pain relief can be achieved with aspiration of joint fluid followed by intra-articular injection of a corticosteroid.

A joint should not be injected more than three or four times in one year because of the possibility of cartilage damage from repeated injections. Patients who require more than three or four injections per year to control symptoms are probably candidates for surgical intervention.

Patients with painful osteoarthritis of the hip may benefit from intra-articular corticosteroid injections. These injections should be performed under fluoroscopic guidance (43).

Intra-articular Injections of Hyaluronic AcidLike Products. Hyaluronic acid is a major nonstructural component of the synovial and cartilage extracellular matrix. It confers viscoelastic and lubricating properties to the joint. In patients with osteoarthritis, the concentration and the molecular weight of hyaluronic acid are decreased. Thus, viscosupplementation with hyaluronic acidlike products is thought to be a possible treatment for osteoarthritis.

Surgery

Patients whose symptoms are not adequately controlled with medical therapy and who have moderate to severe pain and functional impairment are candidates for orthopedic surgery. Osteoarthritis of the knee that is complicated by internal derangement may be treated with arthroscopic debridement or joint lavage. Osteotomy may be performed if significant malalignment of the knee or hip joints is present. Total joint arthroplasty usually has an excellent outcome and markedly improves quality of life (62).

Future Directions

Most investigational therapies are targeted toward the inhibition of collagenolytic enzymes using, for example, oral doxycycline (Vibramycin) or specific metalloproteinase inhibitors. Other developments include tissue engineering using autologous chondrocytes cultured in vitro and reintroduced into the joint. The clinical applications of these approaches are currently limited to research settings

FAI SUBSEQUENTLY PROMOTES THE DEVELOPEMENT OF EARLY OA.

Osteoarthritis is a disorder of diverse etiologies, which commonly can affect the hip (64,67,64).A Workshop on Etiopathogenesis of Osteoarthritis (OA) provided a definition and a classification system for OA that includes a category of patients with idiopathic osteoarthritis, for whom no etiologic factors can be determined (65).

The biomechanical principles for development of OA of the hip generally are based on the calculations of force transmission in that cartilage degeneration is thought to be initiated by concentric or eccentric overload (63,73).A maloriented articular surface with decreased contact area in circumstances such as developmental dysplasia of the hip typically leads to excessive and eccentric loading of the anterosuperior portion and subsequently promotes the development of early OA of the hip (70,71,75).This widely accepted theory implicating axial overload for the onset of OA of the hip fails to provide a satisfactory explanation for development of arthritis in groups of often young patients with apparently normal skeletal structures and intraarticular pressures.

In many cases of idiopathic arthritis, predisposing factors, in the form of femoroacetabular impingement, are present that are not appreciated readily using the traditional diagnostic modalities (66,68,72).The theory implies that in certain aberrant morphologic features of the hip, abnormal contact between the proximal femur and the acetabular rim that occurs during terminal motion of the hip, leads to lesions of acetabular labrum and/or the adjacent acetabular cartilage. The phenomenon is more common in young and physically active adults. The early chondral and labral lesions continue to progress and result in degenerative disease of the joint if the underlying cause of impingement is not addressed (66,69).A previous publication from this institution provided evidence for a type of femoroacetabular impingement to exist (68).

BIOMECHANICS OF THE IMPINGEMENT

On the basis of the pattern and stages of chondral and labral injuries, two distinct types of femoroacetabular impingement have been identified (25).The first type, cam impingement, is more common in young athletic men. It is caused by the jamming of an abnormal femoral head, or head-neck junction (resulting in a reduced head-neck ratio or offset), against the acetabulum, especially with flexion and internal rotation. The prevalence of cam impingement in men is consistent with the finding of external rotation deformities being more common in male children (26).

The second type, pincer impingement, is most common in middle-aged athletic women. It is the result of linear contact between a prominent anterior aspect of the acetabular rim and the femoral head or femoral head-neck junction such as occurs with coxa profunda, acetabular protrusion, or retroversion of the acetabulum (25).The femoral head may have normal morphologic features or may have an indentation caused by the abutment against the prominent anterior aspect of the acetabular rim. The repeated microtrauma may result in an ossified labrum, which compounds the impingement.

Cam and pincer impingement rarely occur in isolation, and the combination has been termed *mixed cam-pincer impingement (27)*.With this disorder, an abnormal femoral head or head-neck junction articulates with an abnormal acetabulum. In one epidemiological study of 149 hips with impingement, twenty-six (17.4%) had isolated cam impingement, sixteen (10.7%) had isolated pincer impingement, and 107 (71.8%) had combined cam-pincer impingement(27).

In the cam type of impingement, the resulting shear forces produce an outside-in abrasion of the acetabular cartilage and/or its avulsion from the labrum and the subchondral bone in the anterosuperior rim area (25).Chondral avulsion in turn can lead to a tear or detachment of the initially uninvolved labrum. In contrast, the first structure to fail when there is pincer-type impingement is the acetabular labrum. The continued impact of the abutment results in the degeneration of the labrum with intrasubstance ganglion formation, or ossification that deepens the socket and increases anterior impingement.

The persistent abutment, which often is anterior, with chronic leverage of the head in the acetabulum can result in injury to the cartilage directly opposite—i.e., in the posteroinferior aspect of the acetabulum (termed the *contre-coup region*) (25).Chondral lesions in hips with pincer impingement often are limited to a small area of the rim and usually include only a narrow strip of acetabular cartilage and therefore are more benign. This is in contrast to what occurs with cam impingement, which can cause deep chondral lesions and/or extensive labral tears (25,28).Arthritis develops when damage at the labral-cartilage junction extends to the articular cartilage and subchondral bone. This damage extends by shearing of the adjacent articular cartilage from the underlying subchondral bone (29,30).In the aberrant, nonspherical area of the femoral head in young patients with femoroacetabular impingement, the hyaline cartilage showed clear degeneration similar to that in hips affected by osteoarthritis (31).Wagner et al. (31).Described damage to the acetabular cartilage as a result of impingement in young patients, and Leunig et al. (32).Observed damage to the acetabular cartilage and labrum resulting from impingement in elderly patients without arthritis.

THE ETIOLOGY OF FAI

The etiology of femoroacetabular impingement is not entirely clear and is felt to be either developmental or related to subclinical slipped capital femoral epiphysis (5,8). A number of conditions can predispose a patient to femoroacetabular impingement including Legg-Calve-Perthes disease, congenital hip dysplasia, slipped capital femoral epiphysis, avascular necrosis of the femoral head, ununited femoral neck fractures, coxa profunda, coxa vara, protrusion acetabuli, and acetabular retroversion (2,4,5,8,12). Slipped capital femoral epiphysis and femoroacetabular impingement have been proposed to be associated due to reduced clearance of the joint and detectable abutment of the metaphysis against the acetabular rim (4). Acetabular anatomic abnormalities (ie, retroverted acetabulum) or proximal femoral anatomic abnormalities (ie, coxa profunda) lead to the pincer-type femoroacetabular impingement (8,10). Those anatomic abnormalities that lead to abnormal sphericity of the femoral head (osseous prominence at the anterolateral femoral head and neck junction, slipped capital femoral epiphysis, and developmental dysplasia of the hip) can lead to cam impingement (8,11).

THE DIAGNOSIS OF FAI

Clinical

The gold standard is clinical diagnosis with radiographic corroboration; however, patients can have radiographic findings and be asymptomatic due to early disease or overall decreased activity (1).Patients often report intermittent pain early in the course of the disease, followed by more consistent pain after demanding activities or prolonged sitting (4,6,10,13). Other exacerbating activities can include stair climbing, prolonged sitting, and athletic events (10,11).

Patients with femoroacetabular impingement typically experience groin pain. Symptoms are typically unilateral and worse after prolonged periods of sitting or when significant stress is placed on the hip (8).Impingement mainly involves the anterolateral portion of the hip joint. Therefore, flexion and internal rotation lead to symptomatic impingement due to shear forces or compression of the acetabular labrum (2,4,8).

The impingement test involves rotating a supine patient's hip internally as it is flexed passively to approximately 90° and adducted (4).A positive "impingement sign" is pain in flexion-internal rotation. On examination, limited range of motion (ROM) frequently is encountered and is described as a loss of internal rotation out of proportion with other ROM deficits (1,4,8).Additionally, a grinding or popping sensation can be felt when the femur is externally rotated and the hip is maximally abducted (8).This sign is sensitive but not specific for femoroacetabular impingement, because the anterolateral labrum is frequently involved in other degenerative diseases of the hip (2,10).

Radiographs

Standard standing anteroposterior and lateral radiographs of the pelvis are necessary for radiographic evaluation (2,4).Proper technique is required, as poorly obtained radiographs may lead to over- or underestimation of the degree of disease (1).Early osteoarthritic changes associated with femoroacetabular impingement are frequently atypical (1).For example, instead of the typical joint space narrowing, osteophyte formation, subchondral sclerosis, or cysts, radiographs of femoroacetabular impingement may demonstrate reactive ossification of the labrum or possibly acetabular rim fractures from repetitive stress (1).Radiographs of both types of femoroacetabular impingement demonstrate premature degenerative arthrosis, and up to one third of patients will have fibrocystic changes at the femoral head-neck junction (8,10). Herniation pits also may be found in the anterolateral portion of the femoral head/neck or morphologic changes affecting the acetabulum (2,4,8,11).

Radiographic signs of pincer impingement include acetabular retroversion and evidence of impaction between the anterosuperior acetabulum and anterior femoral neck (8,9). Retroversion can be diagnosed by the presence of the “crossover” or “figure-of-eight” sign, in which focal retroversion of the superior hip joint exists. The superior aspect of the anterior acetabular rim extends lateral to the posterior rim on frontal radiographs, and computed tomography may be helpful in presurgical planning (9,10,13).Acetabular retroversion is associated with the development of hip osteoarthritis. The prevalence of radiographic acetabular retroversion is 20% among patients with idiopathic hip osteoarthritis and 5% among the general population (14).

Lateral radiographs in cam impingement can demonstrate an osseous prominence at the anterolateral head-neck junction that extends beyond the spherical portion of the femoral head. In addition, the difference between the femoral head and neck planes aligned parallel to the femoral neck axis should normally be >7 mm. Cam impingement may have reduced offset of the femoral neck and head junction .Also, a head to neck ratio can be calculated by determining the difference between the maximal anterior radius of the femoral head and the anterior radius of the adjacent femoral neck (8,12).A pistol grip deformity of the proximal femur and changes of the acetabular rim may also be detected with radiographs (4,8,9,12).

MR & MR arthrography

The hip joint is situated deep within the body and has relatively small structures that can have significant consequences clinically (76).Because of its location and the size of structures, high-resolution imaging is required to delineate normal anatomy and pathologic processes. Introduction of fluid into the joint results in distention of the joint and better separates the intra-articular structures, thus allowing adequate visualization at magnetic resonance (MR) imaging. Addition of dilute gadolinium further enhances the ability to identify pathologic processes involving the hip joint because of its ability to take advantage of the T1-shortening effect of gadolinium and thus extend the dynamic range of contrast seen at MR imaging.

HIP ARTHROGRAPHY

Many techniques have been described for performing hip arthrography. Currently, the most commonly used technique involves fluoroscopic guidance during needle introduction into the hip joint. The most common approaches are anterior, anterolateral, and, occasionally, straight lateral approaches. In most cases, the anterior/superior head-neck junction of the proximal femur is the target as this region typically has a relatively capacious capsule and allows easy introduction of the needle into the joint

A straight anterior approach with the patient's leg in slight internal rotation allows positioning of the femoral neck in the coronal plane and aids in visualization of the junction of the femoral head and the femoral neck.

Following sterile preparation and draping of the region, lidocaine is used for local anesthesia. Subsequently, using fluoroscopic guidance, a 22G spinal needle is introduced into the hip joint. Intra-articular position is confirmed with injection of ~1 to 2 mL of iodinated contrast material. Once intra-articular position is confirmed, ~12 mL of a mixture of dilute gadolinium, iodinated contrast material, and lidocaine is injected into the hip joint. The exact volume depends on the patient's size and joint capacity. If a significant delay is expected between the injection of the contrast material and MR imaging, some have advocated adding epinephrine to the solution to delay resorption of the contrast material from the joint. In general, MR imaging should begin within 20 minutes of intra-articular injection of contrast material.

MR IMAGING TECHNIQUE

Because of its location deep within the body and small intra-articular structures, the hip joint is difficult to image at MR. Currently, there are no commercially available specialized hip coils, although some are under development. Depending on the available hardware, software, and coils, a variety of options are possible. Using a large flex coil or a torso coil results in high-quality imaging of the hip. In addition, multichannel cardiac coils can be used if the hardware and software available support such a coil. When the patient is placed into the bore of the magnet, the toes are taped in slight internal rotation. This aids in bringing the femoral neck into the coronal plane.

Standard imaging planes include axial, coronal, and sagittal images. In addition, an oblique plane is typically prescribed. In the literature, this has been referred to as oblique axial or oblique sagittal imaging. The oblique plane is prescribed off a coronal image through the middle of the femoral neck. The oblique cuts are oriented parallel to the femoral neck

As with MR imaging of most joints, a wide variety of sequences are used depending on hardware and software configurations as well as on personal preference. A small field of view (12-16 cm) should be used in all cases. Depending on the sequences being used, the smallest possible slice thickness should be used. In general, slice thickness should be kept below 4 mm without interslice gap. Imaging time should be limited to less than 5 minutes per sequence to minimize patient's motion and associated blurring of the image.

In general, as with most MR arthrographic studies, the majority of sequences are T1-weighted sequences with or without fat suppression to take advantage of the T1-shortening effect of the dilute gadolinium. Although traditionally conventional spin echo imaging was used, with current configurations, fast spin echo/turbo spin echo is much more commonly used. In addition, some groups have used volumetric acquisitions. When using fast spin echo T1-weighted imaging, the echo train (turbo factor) should be kept at or below 4 to minimize blurring from longer echo trains. A high-resolution matrix should be used in all cases for adequate visualization of small intra-articular structures. Depending on slice thickness and field of view, an asymmetric matrix such as 320-384 × 192 can be used. Although the use of radial imaging has been described in the literature to better visualize the acetabular labrum, a recent study suggests that if standard imaging planes include the oblique plane, radial imaging does not typically reveal acetabular labral tears that were not previously identified (77).

NORMAL ANATOMY

MR arthrography is predominantly used to assess the acetabular labrum and both acetabular and femoral cartilage. However, arthrography also aids in assessing ligaments associated with the hip joint. Finally, in the appropriate setting, loose bodies are often better seen with contrast introduced into the joint.

The acetabular labrum is a somewhat triangular fibrocartilage structure that, in most cases, is closely adherent to the osseous acetabular rim and adjacent cartilage (78).The labrum deepens the socket of the hip joint, although its role in hip stability remains unclear (79,80). The labrum is present in approximately two thirds to three fourths of the circumference of the acetabulum and is absent along the anterior inferior aspect of the acetabulum. Because of its fibrocartilage composition, the acetabular labrum should be low in signal on all pulse sequences

As with the glenoid labrum, there are some peculiarities in anatomy that may mimic labral tears. The most common is the junction between the acetabular labrum and the transverse acetabular ligament, which spans the inferior aspect of the acetabulum along the acetabular notch. There is a normal cleft along the anterior/inferior and posterior/inferior labrum near its junction with the transverse ligament. As gadolinium enters this cleft, the appearance can mimic a labral tear

In addition, along the superior-lateral aspect of the joint, there is a normal recess just superficial to the superior labrum. The presence of gadolinium adjacent to the labrum in this location should not be misinterpreted as either a labral tear or, depending on the imaging plane, a paralabral cyst .An additional cleft can be present normally near the posterior inferior labrum (81).Although there is some evidence in the literature that a normal sulcus may exist between the labrum and the adjacent cartilage along the anterosuperior aspect of the acetabulum, this idea is not yet widely accepted (82,83,84).

The ligamentum teres, which is present in nearly all individuals, is a strong ligament that extends from the fovea capitis of the femur to the acetabulum, where it attaches on both sides of the acetabular notch and blends with the transverse ligament of the acetabulum .When seen in cross-section, such as on axial images, the ligamentum teres may mimic an intra-articular loose body .However, if one follows the structure on contiguous axial images, or cross-references to coronal images, this pitfall can be avoided

The zona orbicularis is a condensation or thickening of the circular fibers of the joint capsule. This is clearly seen on both oblique and coronal images of the hip at MR arthrography . The zona orbicularis is typically located along the more lateral aspect of the femoral neck. Although the capsule extends lateral to the zona orbicularis (lateral compartment of the hip joint), the joint in this region is much less capacious. Thus, it is important to avoid the region of the zona orbicularis while placing the needle into the joint during arthrography, as access to the joint in this region can be tenuous.

Although there are many bursae around the hip joint, the two that most commonly communicate with the joint are the iliopsoas bursa and the obturator externus bursa.

The iliopsoas bursa communicates with the hip joint in ~15% of the population(85).Because of its location along the anterior aspect of the hip, gadolinium within the iliopsoas bursa can be mistaken for a paralabral cyst . The obturator externus bursa communicates with the hip joint typically inferiorly and slightly posteriorly. Its prevalence is unknown. However, when distended, the bursa can protrude anteriorly and medially and thus also mimic a paralabral cyst if it fills with gadolinium at MR arthrography (86).

CAM IMPINGEMENT

In cam-type impingement of the hip, the predominant abnormality is in the contour of the proximal femur, typically the anterior/superior femoral head-neck junction. In pure cam-type impingement, the acetabulum has a normal morphology. Cam-type impingement is most commonly seen in young athletic males.

In cam-type impingement, the anterior/superior femoral head-neck junction, which normally has a concave configuration, becomes either flattened or convex. In addition, because of this morphologic abnormality, the femoral head may become somewhat aspherical. The exact etiology of this abnormal femoral head-neck offset is not clear. Although some have suggested that it may be due to a subclinical slipped capital femoral epiphysis, there is other evidence that suggests that the abnormal morphology is due to abnormal separation of the common physis of the femoral head and the greater trochanter during development (98).As the hip is placed in flexion and internal rotation, because of the loss of the normal concavity in this region, the femur abnormally touches the acetabular rim.This abnormal contact results in damage to the cartilage, typically predominately the acetabular cartilage, and the acetabular labrum.

On radiographs, the abnormal morphology of the femoral head-neck junction can be seen on anteroposterior (AP) views, frog lateral views, and true lateral views. Often, these abnormalities can be subtle to the unsuspecting eye. On an AP view of the hip, the normal concavity along the lateral aspect of the femoral head-neck junction becomes flattened or slightly convex .Traditionally, this has been referred to as the pistol grip deformity. More recently, it has been ascribed to abnormal epiphyseal extension. The same abnormality can be seen on the frog lateral view, although craniocaudal angulation must often be employed to prevent the greater trochanter from obscuring visualization of the head-neck junction.On a true lateral view, again seen is loss of the normal concavity along the anterior femoral head-neck junction .

The same morphologic abnormalities can be seen at MR imaging. The epiphyseal extension is best seen on coronal sequences as they most closely approximate the AP view of the hip. However, the abnormal femoral head-neck offset on the anterior/superior head-neck junction is often best seen on oblique (oblique axial or oblique sagittal) images that parallel the femoral neck. Although intra-articular gadolinium is not necessary to assess the morphologic abnormality of the proximal femur, MR arthrography does aid in visualization of the cartilage lesions and labral lesions that are often associated with femoroacetabular impingement .

Many quantitative methods have been described to measure the sphericity of the femoral head as well as the abnormal offset at the femoral head-neck junction. These include measurement of epiphyseal extension, the amount of femoral head-neck offset, and the α angle (88,89,90). The α angle may be the most convenient when reading cases off a clinical workstation as the necessary tools for measurement are available on most clinical workstations and the angle can be measured in a matter of seconds.

The α angle is measured off an oblique image through the center of the femoral neck. A line is drawn along the long axis of the femoral neck bisecting a circle that outlines the femoral head. A second line is then drawn from the center of the circle to the point at which the femoral head or neck protrudes beyond the confines of the circle anteriorly. The angle formed by these two lines is the α angle. In a study by Notzli et al, all patients with impingement had an α angle of 55° or greater whereas those of the control group had an α angle less than 48°(89). Thus, it appears that an α angle greater than 50° is abnormal, although using a threshold of 55° may be more specific to impingement triad of MR arthrographic findings has been described in patients with cam-type femoroacetabular impingement (87). The triad consists of an abnormal α angle, an anterior/superior acetabular cartilage lesion, and an anterior/superior acetabular labral tear. In that study, ~90% of patients with clinical impingement had the triad of MR arthrographic findings.

PINCER IMPINGEMENT

In pure pincer-type impingement, the proximal femur has a normal contour. The predominant abnormality is with the morphology of the acetabulum. Abnormalities in acetabular morphology include acetabular retroversion, anterior or lateral overcoverage, or both, and protrusio acetabuli.

Evaluation of acetabular morphologic abnormality can be challenging on imaging because of the complex orientation and anatomy of the acetabulum. On a properly positioned AP view of the pelvis, the anterior rim of the acetabulum should always project medial to the posterior rim of the acetabulum. In patients with retroversion, the anterior rim of the acetabulum projects lateral to the posterior rim of the acetabulum. This typically involves the superior half of the acetabulum. Thus, the edge of the anterior and posterior rim of the acetabulum crosses over on the AP view of the pelvis, the so-called crossover sign . However, care must be taken as slight craniocaudal angulation can either mimic or obscure true retroversion of the acetabulum. On cross-sectional imaging (computed tomography or MR), retroversion can be identified if the anterior rim of the acetabulum is lateral to the posterior rim on the first axial image that includes the femoral head (91).

Acetabular overcoverage can also be seen on an AP view of the pelvis. This can be identified as abnormal lateral extension of acetabular rim often with a somewhat downward sloping of its most lateral portion . In addition, a false profile view of the hip can be used to assess for abnormal anterior overcoverage by the acetabulum (92).

In pincer-type impingement, the cartilage lesions are often seen along the posterior aspect of the acetabulum because of a contrecoup type of injury as the femur abnormally touches the acetabular rim. The associated labral degeneration and tears are most common in the anterosuperior labrum.

The exact association between so-called synovial herniation pits of the femoral neck and femoroacetabular impingement is not entirely clear (93).A recent study suggests that there is a high prevalence of these cysts in patients with femoroacetabular impingement (94).However, another study, which focused on patients with cam-type femoroacetabular impingement, demonstrated that only 5% had these cysts (87).Thus, it is possible that these cysts are more common in patients with pincer-type impingement than in those with cam-type impingement.

In addition, an association between an os acetabuli and hip impingement has been suggested. Some believe this is heterotopic bone formation on the acetabular rim related to abnormal contact with the femur.The mineralization may be in the soft tissues or in the labrum

It should be noted that although femoroacetabular impingement has been classified as cam type and pincer type, in reality, many patients have components of both although one component may predominate.Thus, treatment of femoroacetabular impingement should address potential abnormalities of both the femur and the acetabulum in all cases.

Computed Tomography Scans

Although not typically used in you patients with hip pain, CT scans, with or without intra-articular contrast, can show some of the lesions associated with impingement. High-quality scans with multiplanar reformatting can demonstrate all the osseous abnormalities described in hip impingement. Addition of intra-articular contrast also allows visualization of the labrum and cartilage (98).Given that many of these patients are young, CT is typically limited to patients who cannot undergo MR imaging or those in whom the detailed osseous anatomy cannot be adequately delineated with the combination of MR and radiographs.

CT is primarily used for optimal evaluation of the bony anatomy that may be seen in patients with FAI (101).Beaule et al used three-dimensional CT to assess the anterior and posterior concavity of the femoral head-neck junction in 36 patients with painful nondysplastic hips. They found that that three-dimensional CT was an accurate tool to quantify the femoral head-neck concavity (101).A recently published article presented a novel technique using a CT-based navigation system for a three-dimensional evaluation of FAI(100). The method allowed an anatomically based calculation of hip range of motion and an exact location of the impingement zone (100).Although CT imaging can provide great visualization of bony abnormalities associated with FAI, the evaluation of intra-articular pathology is more limited with this imaging technique. Labral tear and chondral lesions are often missed using plain CT imaging. The MDCT arthrography of the hip, however, is a very useful tool for evaluating the labral pathology in patients that cannot undergo MRI procedures. It is possible that MDCT arthrography may gain popularity in the future for the evaluation of patients with suspected FAI (99).

THE TREATMENT OF FAI

The first therapeutic step in treatment is nonsteroidal anti-inflammatory drugs and activity modification (2,9,10). Additionally, physical therapy is aimed at strengthening abdominal and gluteal musculature and stretching the paravertebral muscles to change posture or pelvic inclination (2).Specific movements that elicit symptoms should be avoided.

Surgical reconstruction is recommended as early as possible after first symptoms appear to prevent future damage (1).Surgical treatment is suitable only if there are no advanced degenerative changes or extensive articular cartilage damage (6).Once irreversible cartilage damage has occurred, pain will frequently persist after surgical intervention (8).

Joint preserving surgery involves resection osteoplasty and less frequently osteotomy for reorientation (2,4,8).Surgical osteotomy involves removing the osseous protrusion by either surgical hip dislocation or arthroscopy (1,2,4,8,10).Surgical hip dislocation involves entering the hip joint anteriorly via a capsulotomy and reducing either the nonspherical portion of the femoral head in cam impingement or the acetabular rim portion in pincer impingement (8).

Arthroscopic management involves a complete evaluation of both the central and peripheral compartments of the hip joint (9). An intertrochanteric flexion-valgus osteotomy involves increasing the distance between the femoral neck and acetabulum by performing an intertrochanteric osteotomy in patients with avascular necrosis or Legg-Calve-Perthes disease (8).Less commonly, reorientation of a retroverted acetabulum can be performed. This is called reverse periacetabular osteotomy (1,2,4,13). In patients with advanced osteoarthrosis, total hip arthroplasty is an option (2).

METERIAL AND METHODS

A prospective study was designed and the study group was collected over a three month period. Throughout this period we examined 200 patients.

Inclusion criteria for the study was age equal or less than 45 years, and a history of hip or groin pain. The radiographs of the patients were prospectively collected in our clinic. The study included those patients in whom pelvis AP radiograph was requested. No additional radiographs were obtained in order not to expose patients to unnecessary radiation. The study was approved by the ethical committee.

Patients who had an anterio-posterior view of pelvis were included in the study. The plain radiograph has been obtained for each patient. A standard pelvis AP radiogram was obtained by the following technique:

The plain radiographs were carried out on a Siregraph-D1 siemens machine.

Supine position

Film focus distance of 115 cm

kVp 70 (70 - 80)

mAS 60 (40 - 60)

The radiological signs for femoroacetabular impingement syndrome has been evaluated from this AP view. A properly positioned AP radiograph of the pelvis in the supine position provides information about the joint line, depth of the hip joint, and version of the acetabulum. The AP radiographs were assessed for the presence of femoroacetabular impingement syndrome ,and for it's subtypes weather it is Cam impingement at which there is abnormal flattening of the femoral head-neck junction , also refered as bumping , or it is Pincer impingement at which there is acetabular overcoverage or the presence of cross-over sign , or it is mixed of both subtypes. Cam type impingement was decided whenever there is a focal bump over the upper border of the femoral neck. The “pistol-grip deformity”, a horizontal growth plate sign, or a caput-collum-diaphysis angle less than 125 degrees were used as confirmatory signs. A pincer type of impingement was said to be present wnenever there is signs of acetabular overcoverage, namely the “cross-over” sign, coxa profunda, protrusio acetabuli, focal acetabular retroversion and posterior wall sign.

On the other hand, the presence of coxofemoral joint space narrowing, the presence of sclerosis in the femoral head or acetabular roof, the presence of suchondral cyst, the presence of os acetabuli as a secondary impingement sign, the presence of other signs of coxarthrosis, signs of Rheumatoid arthritis, signs of conginital hip dysplasia, and the other deginerative changes were also evaluated.

SHORT DESCRPTION OF CASES WITH FIGURES

CASE # 197

A 17 years old male patient presented with low back pain associated with limited range of movement.

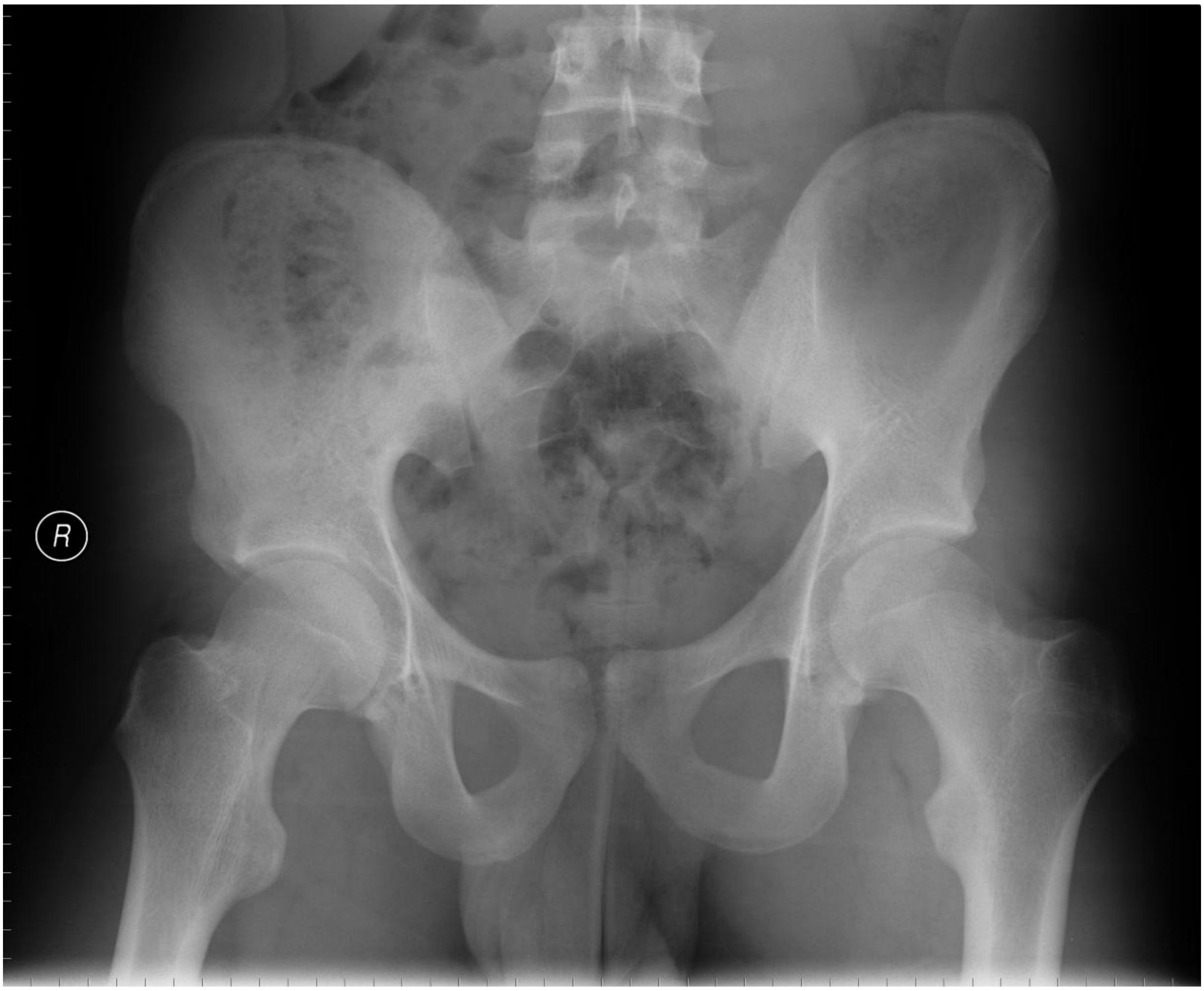

Figure (1)
Anteroposterior view of normal plain radiograph of the hip

CASE # 6
A 37 years old female patient presented with bilateral grion pain associated with swelling in ankle and knee joints

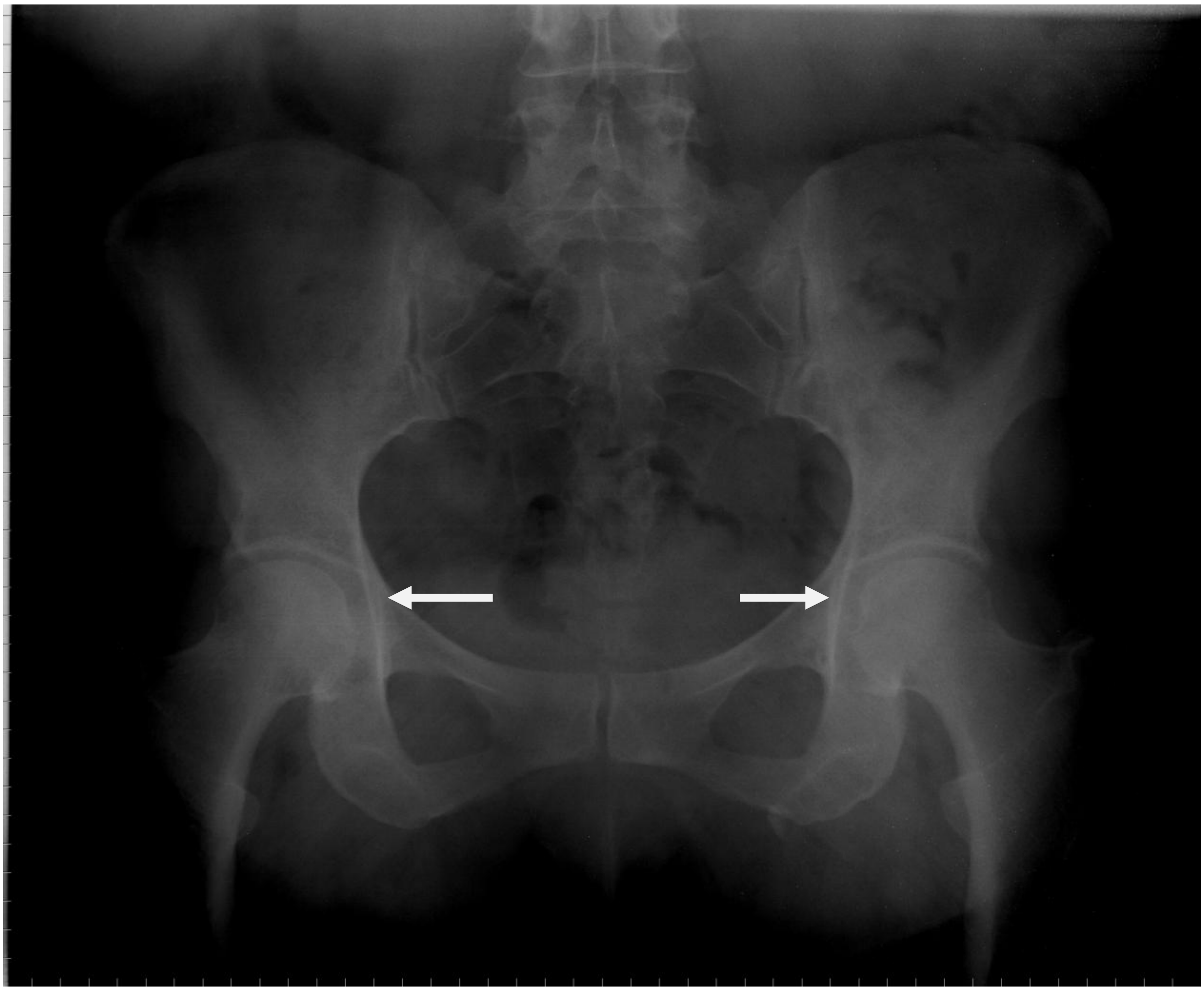

Figure (2)
Anteroposterior view of plain radiograph of the hip shows bilateral acetabular overcoverage with normal femoral head asphericity, referrs to bilateral pincer impingement. Note bilateral coxa profunda (white arrows) deformity.

CASE # 30

A 31 years old male patient presented with bilateral hip pain assocaited with limited range of movement

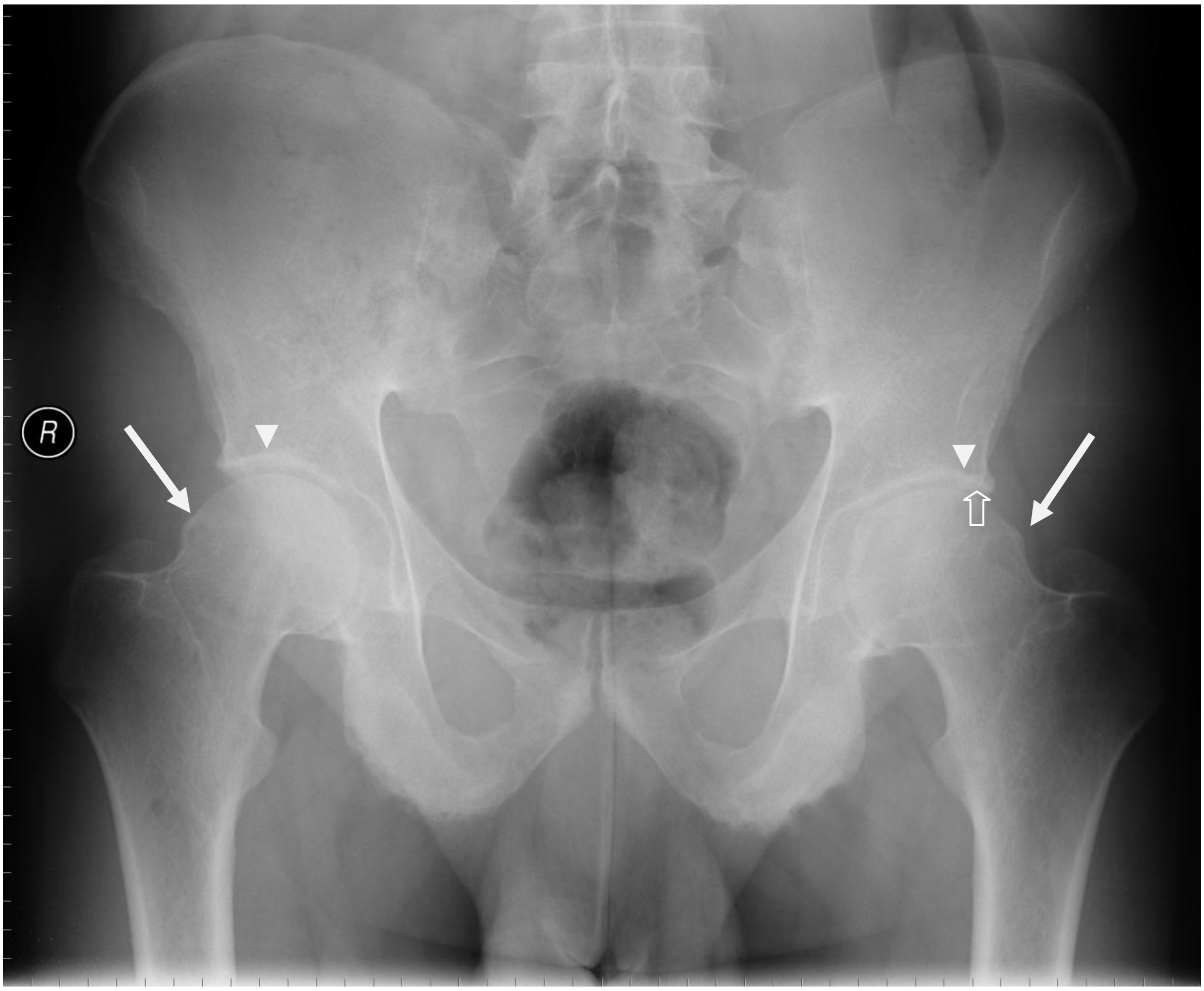

Figure (3)

Anteroposterior view of plain radiograph of the pelvis shows abnormal flattening of the bilateral femoral head-neck junction, this is often referred to as the ‘‘bump’’(white arrows) or “pistol-grip” deformity,it is a typical case of bilateral Cam impingement. Note also sclerosis of the acetabular roof (white arrowheads) and focal joint surface irregularities (open white arrow).

CASE # 17
A 41 years old male patient presented with groin pain associated with limited range of movement

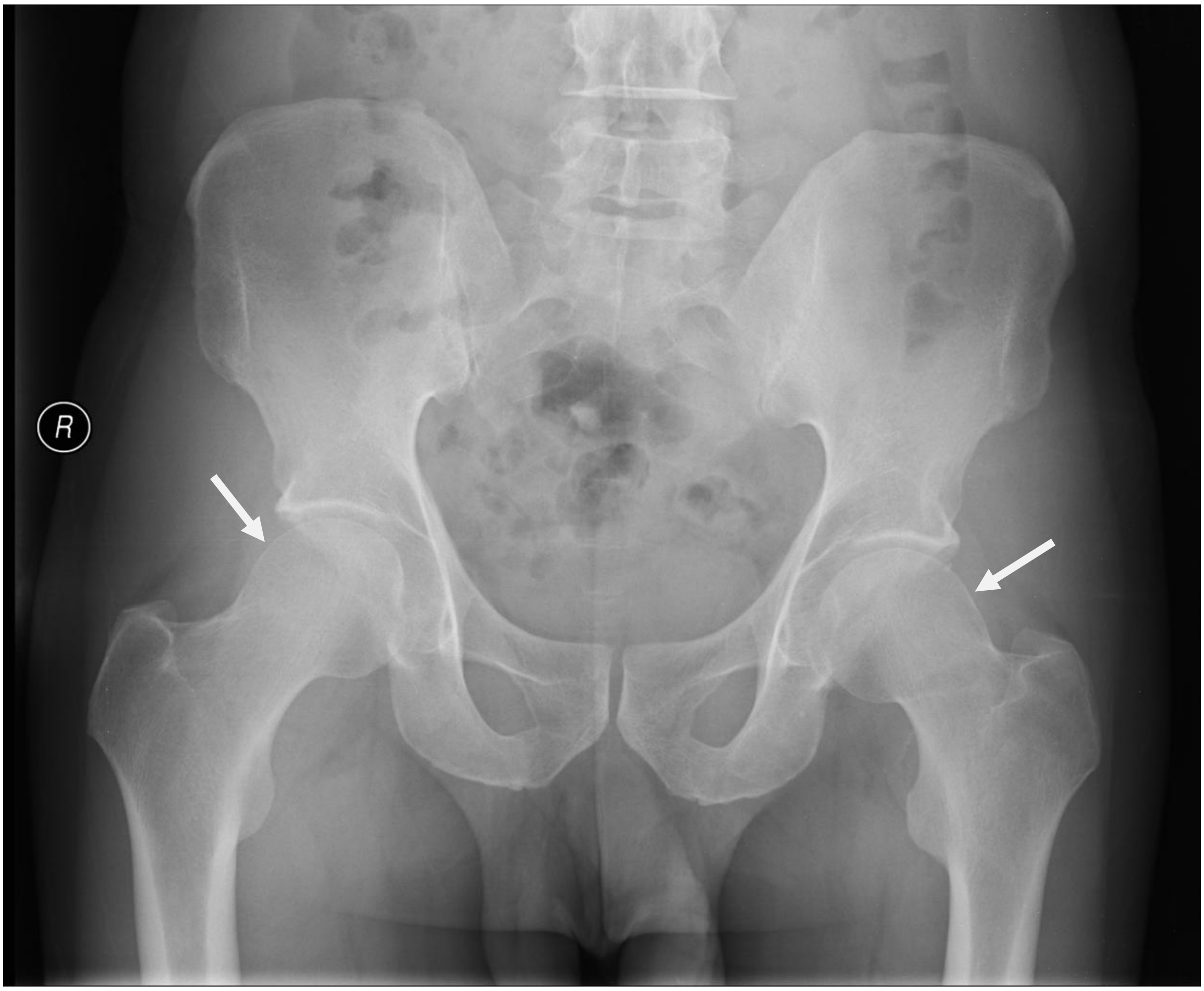

Figure (4)
Anteroposterior view of plain radiograph of the pelvis shows “pistol grip” deformity (white arrows), there is a slight sclerosis in the acetabular roof, the joint space is normal, it is a case of Cam impingement with slight degenerative changes in the joint.

CASE # 59
A 43 years old male patient presented with bilateral hip pain associated with limited range of movement

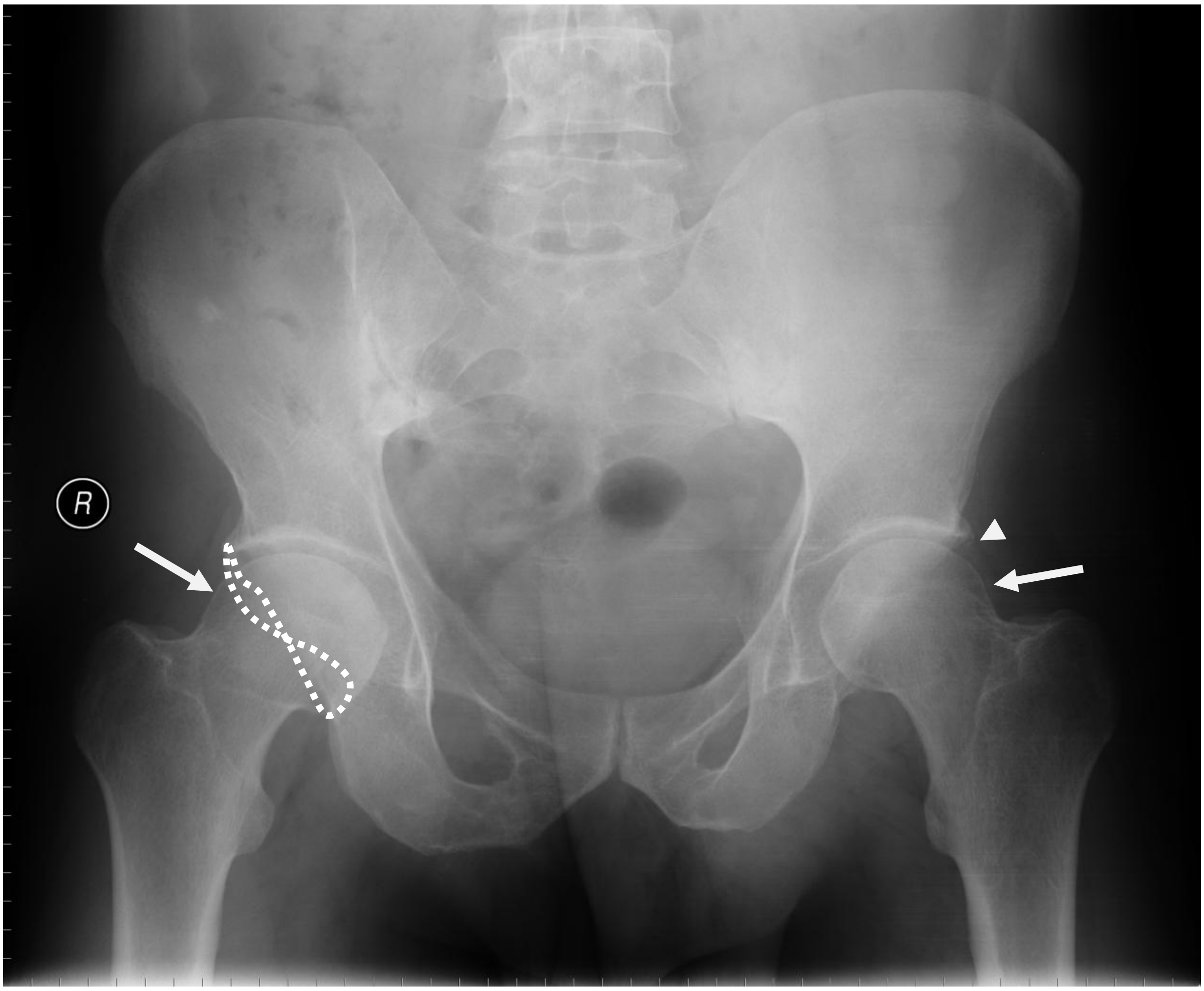

Figure (5)
Anteroposterior view of a plain radiograph of the hip shows abnormal flattening of the femoral head-neck junction in both sides (white arrows), the bilateral acetabular overcoverage ("cross-over" sign, dashed lines) is also seen in this film. The both subtypes of femoroacetabular impingement(Cam and Pincer) is seen in this patient and referrs to the mixed femoroacetabular impingement syndrome. Note also os acetabuli (white arrowhead) on the left side.

CASE # 125

A 34 years old male patient presented with a low back pain associated with limited range of movement

Figure (6)

Anteroposterior view of plain radiograph of the pelvis. There is complete fusion of both sacroiliac joints, it is a typical case of sacroilitis. On the other hand the bilateral coxofemoral joints appear normal.

CASE # 112
A 36 years old male patient presented with bilateral hip pain associated with limited range of movement

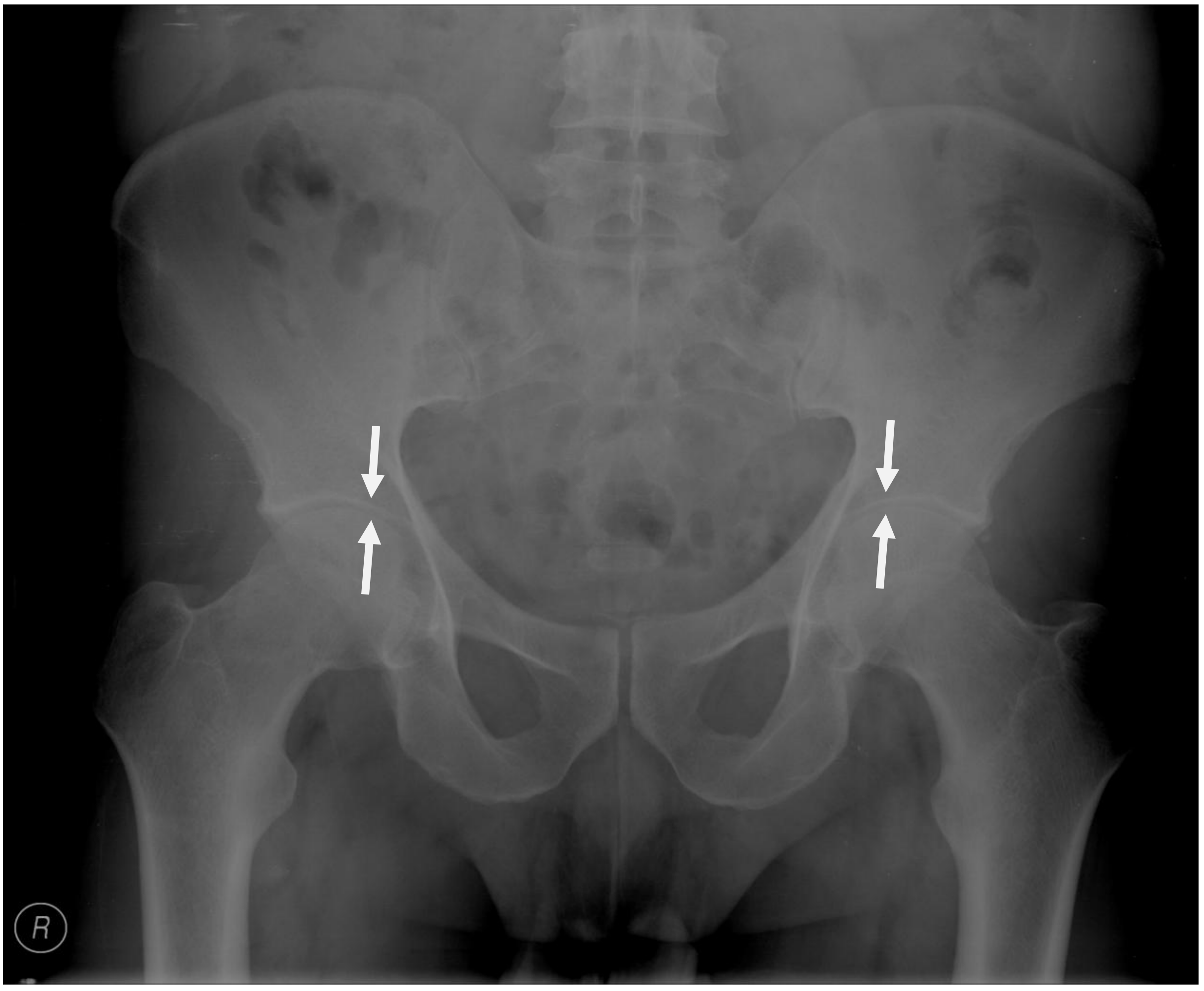

Figure (7)
Anteroposterior view of plain radiograph of the hip shows diffuse symmetrical narrowing (white arrows) of bilateral coxofemoral joint space, in this film, there are no signs of femoroacetabular impingement syndrome, it was a case of Rheumatoid Arthritis.

CASE # 77

A 35 years old female patient presented with hip pain associated with limited range of movement

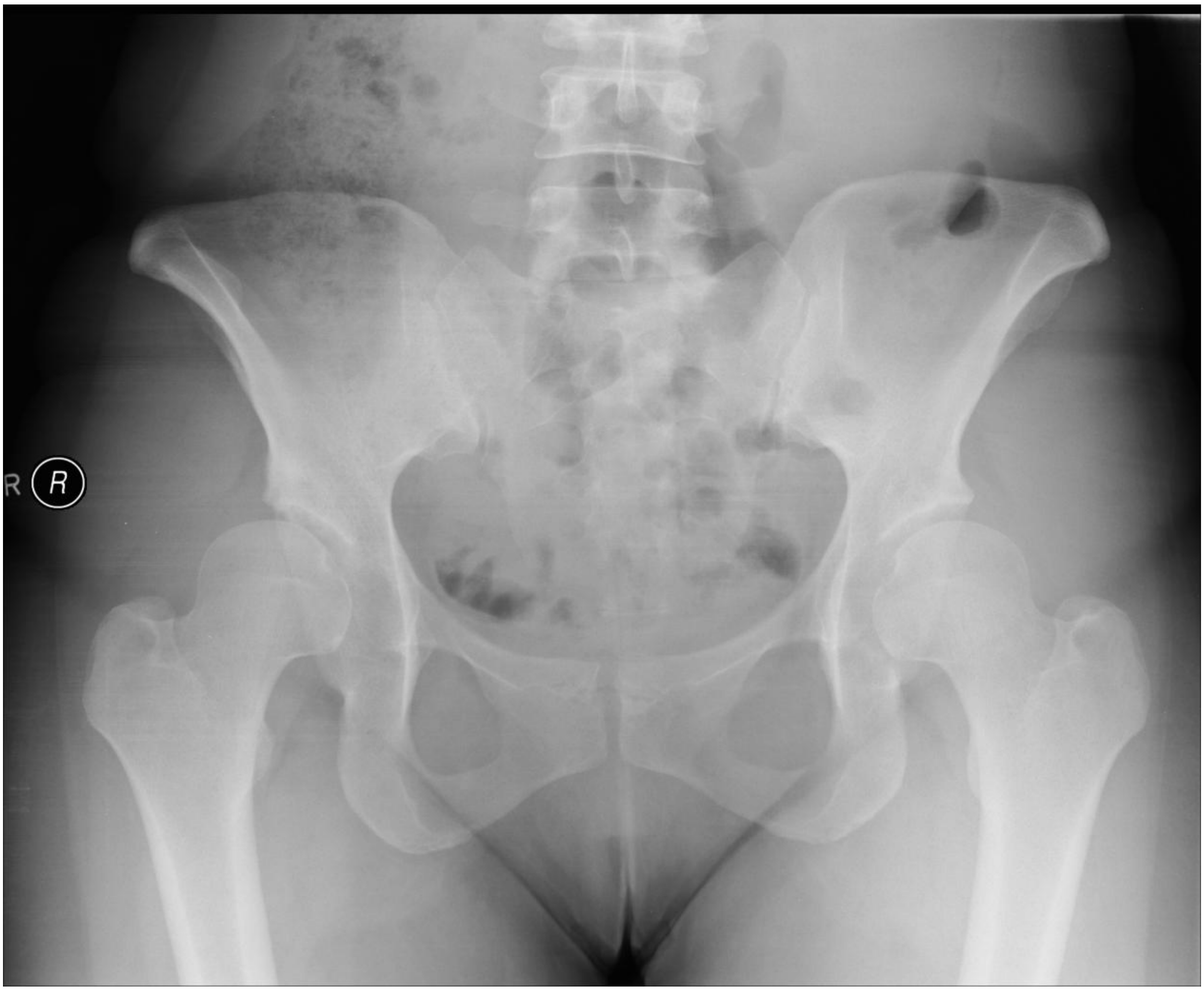

Figure (8)

Anteroposterior view of plain radiograph of the hip shows bilateral shallow acetabulum, referrs to congenital hip dysplasia.

CASE # 49
A 38 years old male patient presented with groin pain associated with limited range of movement

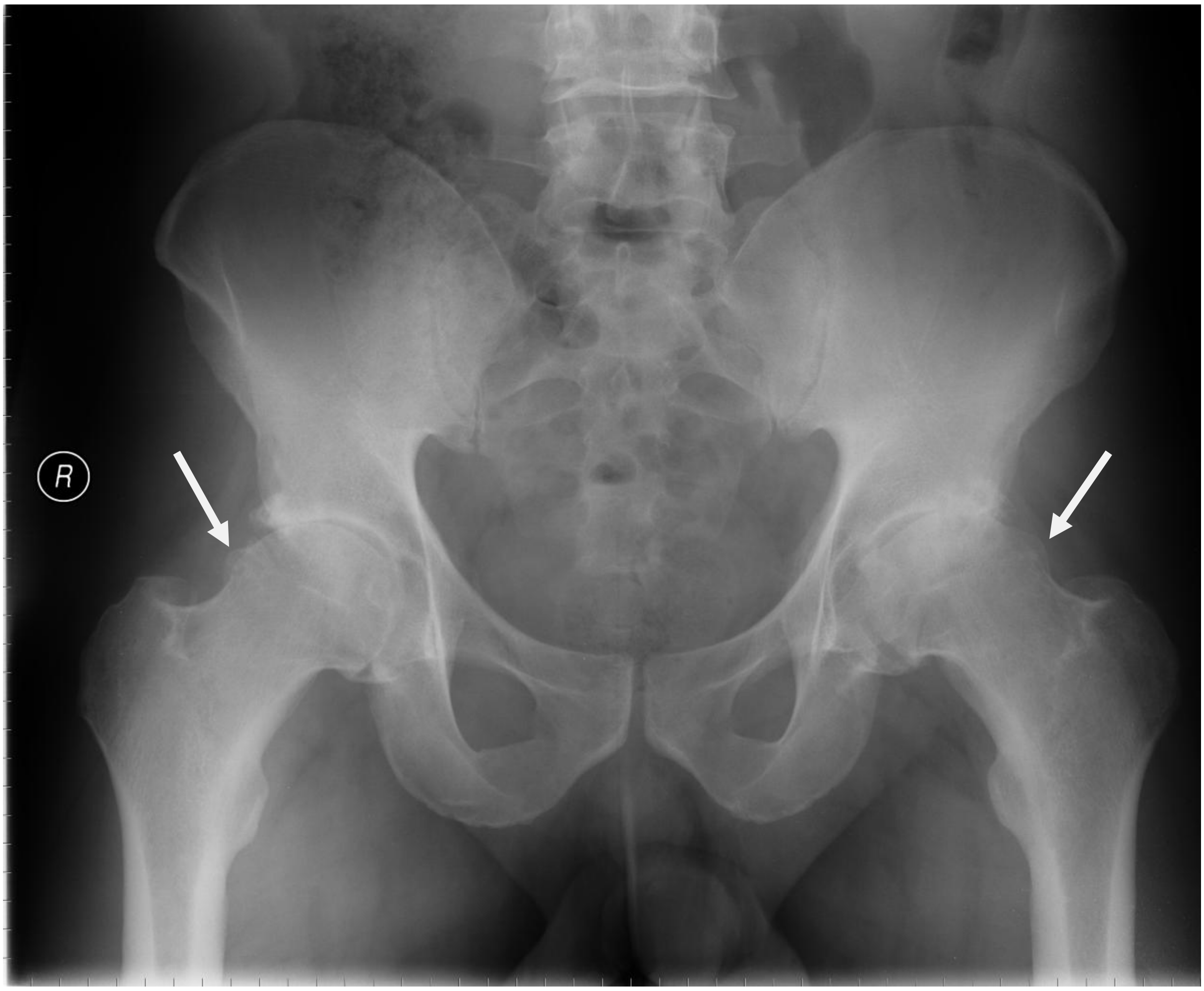

Figure (9)
Anteroposterior view of plain radiograph of the hip at which :
The joint space is significantly narrowed on the left side. The joint surfaces are sclerotic, irregular, subchondral pseudo-cysts are visible in the femoral head. Acetabular new-bone formation (osteophytosis) is present, it is a typical case of coxarthrosis secondary to cam type (white arrows) femoroacetabular impingement.

RESULTS

The plain radiographs for 10 patients were excluded from the study because of hip prosthesis or intramedullary nail fixations.

There were a total of 190 patients who fulfilled the inclusion criteria. The age range was 15 to 45 years (mean: 30 years), there were 102 males (53.6%) and 88 females (46.3%).

The pathologies found at pelvis AP radiographs in these 190 (380 hips) patients are listed in Table 1. Overall there were a total of 20 patients (20/190,10.5%; 25/380, 6.5%) who were identified to have femoroacetabular impingement on pelvis radiographs.

Of these patients 15 had signs of cam type femoroacetaular impingement (7.9%), 4 had signs of pincer type impingement (2.1%), and 1 (0.5%) had signs of mixed femoroacetabular impingement on radiographs. Fourteen of the cases were males and only 1 case was female.

Of the cam type impingements 10 of them were bilateral (20 hips), 4 cases were having the impingement in the right side only , while only 1 case was having left sided cam impingement. All cases were male.

Of the pincer type impingements 3 cases were bilateral (6 hips), while only 1 case was having right sided pincer impingement. Three cases were females and only 1 case was male.

Degenerative arthritis secondary to femoroacetabular impingement were seen in 6 cases (6/190, 3.1%; 6/20, 30%) . Of them 5 cases had cam type femoroacetabular impingement, and one case had pincer type impingement. The presence of os acetabuli as a secondary impingement sign was seen in 1 case (0.5%), it was on the left side.

The presence of degenerative arthritis were seen in 16 cases (16/190; 8.4%). Coxarthrosis were seen in 5 cases, at which it was bilateral in 3 cases (1.5%), it was in the right side in 2 cases (1%). The presence of coxofemoral joint space narrowing alone were seen in 4 cases (2.1%),3 (1.5%) were in the right side and 1(0.5%) was in the left side. The presence of femoral head or acetabular roof sclerosis alone were seen in 6 cases (%3.1). The presence of subchondral cyst alone was seen in 1 case (0.5%).

The presence of Rheumatoid arthritis were seen in 3 cases (1.5%).

The presence of sacroilitis were seen in 8 cases(4.2%) , 7 cases(3.6%) were bilateral and 1 case(0.5%) was in the right side.

The presence of the conginital hip dysplasia were seen in 8 cases (4.2%), 6 cases(3.1%) were bilateral ,1 case(0.5%) was in the left side and 1 case (0.5%) was in the right side.

Table 1.

Pathologies on pelvis radiographs

PATHOLOGY		NUMBER OF PATIENTS
NORMAL		134
FEMOROACATABULAR IMPINGEMENT	CAM TYPE	15
	PINCER TYPE	4
	MIXED	1
DEGENERATIVE OSTEOARTHRITIS		16
INFLAMMATORY ARTHRITIS	RA	3
	AS	8
OTHERS		Hip dysplasia : 8 , aneurysmal bone cyst : 1

RA, rheumatoid arthritis; AS, ankylosing spondylitis.

DISCUSSION

Pain at the hip joint is a common symptom and patients present with difficulties performing activities of daily living and sports. Decrease in hip range of motion is worse in the presence of osteoarthritis. Femoroacetabular impingement is beginning to be recognized as a potential cause of hip pain, labral pathology, chondral damage, and eventually osteoarthritis. We feel that it is very important to recognize and address these bony abnormalities during the evaluation and treatment of pain in the hip, as well as pain in other surrounding areas.

Complaints of groin pain, pain over the greater trochanter, or buttock pain are extremely nonspecific. The differential diagnoses for these complaints are numerous and certainly not limited to pathology of the hip. Failure to identify FAI as the cause of symptoms may lead to unnecessary tests and even inappropriate interventions (102).

Femoroacetabular impingement is a clinical condition that usually presents in physically active young adults with an age range of 30 to 40 years. The clinical presentation consists of intermittent hip or groin pain that may be exacerbated by physical activity. Hip examination is directed toward showing clinical impingement. With the patient supine, the hip is internally rotated, flexed passively to 90°, and adducted. This test leads to abutment of the femoral neck against the acetabular rim, precipitating pain on forceful internal rotation if a labral or chondral lesion is present (103).

Two subgroups of femoroacetabular impingement have been described, the "cam" and the "pincer" types, although some overlap may exist between the two (104).

The cam type is more common in young athletic men and involves abutment of an abnormally shaped femoral head into the acetabular rim, particularly during hip flexion. This leads to chondral and labral injury secondary to the shearing forces produced. This conflict occurs in an "outside in" fashion, with tears occurring at the attachment of the labrum to the acetabular rim, leaving the body of the labrum substantially intact (105).Widening of the femoral neck or reduced excursion of the femoral head and neck junction has been implicated in reducing femoral head clearance and thereby providing a potential source of femoroacetabular impingement (106,107,108).An osseous prominence found at the anterolateral femoral head and neck junction might also be implicated in the pathogenesis of femoroacetabular impingement. An osseous prominence has been associated with several disorders, including chronic slipped capital femoral epiphysis, posttraumatic deformity, abnormalities resulting from prior surgical osteotomy, reduced antetorsion of the femoral head, and residual childhood diseases such as Perthes' (Legg-Calvé-Perthes) disease (106, 107,109-111).We found signs of cam type impingement in (7.9%, overall FAI 10.5%) in our young patients who presented with hip pain. In the literature the incidence of femoroacetabular impingement is reported to be ranging between (10.7 % to 17.4%). The data in the literature and in our are in concordance, and siginificantly imply more attention during the clinical evaluation of especially young patients with hip pain. It is also worth to emphasize that our results suggests further clinical and/or radiological evaluation of these young patients. Pelvis AP and lateral radiographs of the affected hip may exhibit apparent signs of femoroacetabular impingement. Probably additional radiographs, especially cross-table views, are necessary for further work-up of these patients.

The pincer type, which is more common in middle-aged women, involves contact between the acetabular rim and the femoral head and neck junction (104).In a similar fashion, an abnormal acetabulum may also reduce femoral head clearance and provide a potential source of impingement. Anterior acetabular overcoverage (acetabular retroversion) (112).protrusio acetabuli (113).and coxa profunda (113).Have been implicated as causes of impingement. Both the cam and pincer types may contribute to the repetitive conflict between femur and acetabulum. Such conflict causes a shearing force to be applied to the acetabular labrum and adjacent acetabular hyaline articular cartilage, leading to degeneration and the subsequent development of hip osteoarthritis (104).

It has been suggested that the repetitive microtrauma between the femur and the acetabular rim causes tearing of the labral-chondral transitional zone, particularly in the anterosuperior region. This may then predispose the adjacent articular cartilage to degeneration in the form of softening, fraying, and separation. Ultimately, articular cartilage detachment or fragmentation may occur, leading to exposure of bare bone and the subsequent development of osteoarthritis. In our study we found osteoarthritis related to femoroacetabular impingement in 6 cases. This corresponded to 3.1% of all the study group, but interestingly it comprised nearly every 3 patient (30%) affected by FAI. This especially increase the importance of this condition prior to development of osteoarthritis.

Various of conditions affecting the acetabulum also can lead to morphologic changes predisposing the hip to impingement. Some of the conditions observed to cause femoroacetabular impingement include acetabular retroversion, coxa profunda, protrusio acetabuli, and posttraumatic deformities. Retroversion of the acetabulum has been described as a posteriorly orientated acetabular opening with reference to the sagittal plane (114).A retroverted acetabulum may occur as part of more complex acetabular developmental deformities, (115).Or it may be seen as an isolated entity (116).Retroversion results in a prominent anterolateral acetabular edge, creating an obstacle for flexion and internal rotation and in turn predisposes the hip to femoroacetabular impingement. This situation is made worse if the prominent acetabular edge impinges against a proximal femur with a low head and neck offset such as seen in hips with a pistol grip deformity (117 ,118).Symptomatic impingement resulting from underlying acetabular retroversion has been treated successfully with reverse periacetabular osteotomy (119).Femoroacetabular impingement that was alleviated by removing the relative anterior over coverage could be confirmed in all patients. Labral and chondral lesions in the anterosuperior region of the acetabulum resulting from the repetitive trauma of impingement were observed in more than half of the patients in the aforementioned series, which may explain the association of acetabular retroversion with development of OA (120).

Early onset hip osteoarthritis in nondysplastic hips is often thought to be “idiopathic.” Increasing evidence, however, supports the theory that morphologic abnormalities of the proximal femur or acetabular rim can lead to a cascade of events leading to osteoarthritis (121).The abnormality seen at the proximal femur is a bony prominence resulting in an abnormal femoral head–neck offset. Acetabular abnormalities include a retroverted acetabulum with localized over-coverage or generalized over-coverage such as with coxa profunda. These abnormalities lead to abnormal contact during terminal hip motion, resulting in lesions of the acetabular labrum or the acetabular cartilage (121,122).The chondral and labral lesions often continue to progress, and if the underlying morphologic abnormalities are not corrected, the result can be premature degenerative joint disease (121).

Radiographic assessment is of extreme importance, as patients with FAI will often have their radiographs read as normal. Useful plain radiographs include a true anteroposterior pelvis film to look at the orientation of the acetabulum (pincer-type FAI), and a cross-table lateral radiograph of the hip to accurately assess the reduced offset at the femoral head–neck junction (cam-type FAI) (121,122,123,124).In cam-type FAI, the normal concavity of the femoral head–neck junction will be replaced by a bony prominence and may actually seem convex. A method to measure this abnormality on radiographs has been described by Eijer et al.(125).One of the drawback of our study was the lack of the “cross-table” view. However we aimed to study the frequency of femoroacetabular impingement in young adults who presented with hip pain. In these patients the AP radiograph of the pelvis and the AP and lateral radiographs of the affected hips are requested and the “cross-table” view is not a routine standard projection during the work-up. It is generally requested whenever femoracetabular impingement is suspected.

On an anteroposterior radiograph of the pelvis, the presence of the “crossover sign” or the “posterior wall sign” indicates acetabular retroversion (123,124).The crossover sign is seen when the anterior rim of the acetabulum (normally more medial and horizontal) crosses over the posterior rim of the acetabulum (normally more lateral and vertical). In addition, the posterior wall of the acetabulum normally descends through the center of the femoral head or lateral to it. In a retroverted acetabulum, the posterior wall can be seen medial to the center of the femoral head, which is known as the posterior wall sign (123).This localized over-coverage leads to reduced hip clearance with premature abnormal contact between the femur and acetabular rim.

Specific magnetic resonance imaging findings are also seen in FAI. Cartilage and labral abnormalities are usually seen in an anterosuperior distribution, or a “12 to 1 o’clock” distribution (126).

Conservative treatment would primarily consist of avoiding positions of impingement. This usually requires significant activity modification. Definitive treatment requires surgical correction of the underlying morphological abnormalities of the femoral head–neck or acetabulum, along with addressing the pathologic changes in the labrum and articular cartilage. In the case of cam (femoral) FAI, resection of the aspherical part of the head–neck junction (resection osteoplasty) is performed (121,122,127).Various surgical procedures have been described, including an open procedure with surgical hip dislocation or a combined hip arthroscopy with a limited open anterior femoral head–neck osteoplasty (121,122,128). In cases of pincer (acetabular) FAI, the over coverage is corrected by a resection osteoplasty of the excessive acetabular rim or by a reorientation procedure, such as a periacetabular osteotomy (122,124,129). The goal of surgery is to improve the clearance of the head–neck junction within the acetabulum and to eliminate the abnormal contact between the femur and acetabulum (122). This should result in decreased pain and improved function for the patient. In addition, if FAI is diagnosed early, the surgery can prevent further hip joint damage and the cascade of events leading to early hip osteoarthritis (121). As FAI has only been relatively recently described, there are few long-term follow-up results of surgical intervention.

CONCLUSION

In conclusion, two main forms of femoroacetabular impingement—pincer and cam—occur in young active individuals presenting with hip pain, although most patients will have a combination of both impingement types. The radiographic technique and typical findings have been presented. MRI and MR arthrography are important for further evaluation of the osseous and soft-tissue abnormalities of impingement

SUMMARY

Purpose : The purpose of our study was to evaluate the plain radiograph in the identification of femoral & acetabular pathologies in young patients suffering from hip or groin pain to assess the frequency of feomoroacetabular impingement syndrome in these patients.

Material & Method : A total of 200 plain radiographs of the hip were collected over a three month period and analysed prospectively, a history of hip or groin pain was present in all cases, an anteroposterior view of plain pelvic radiograph has been taken for each patient and the radiological signs for the femoroacetabular impingement syndrome has been evaluated.

Results : 190 patients fulfilled the study criteria and were eventually included in the study. Twenty patients were found to have FAI (10.5%). Of these patients 15 had signs of cam type femoroacetaular impingement (7.9%), 4 had signs of pincer type impingement (2.1%), and 1 (0.5%) had signs of mixed femoroacetabular impingement on radiographs. Fourteen of the cases were males and only 1 case was female. Degenerativbe arthririts secondary to FAI were seen in 6 cases (3.1 % of total study group; 30 % of patients with FAI).

Findings other than FAI were osteoarthrirtis (16 cases), inflammatory arthritis (11 cases), congenital hip dysplasia (8 cases), and aneurysmal bone cyst (1 case).

Conclusion : In conclusion, two main forms of femoroacetabular impingement—pincer and cam—occur in young active individuals presenting with hip pain and the development of osteoarthritis at an early age makes this condition essential. Further clinical and radiological work-up is necessary when findings suggestive of FAI are present.

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