



Review Article

Femoroacetabular impingement[☆]



José Batista Volpon

Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, Departamento de Biomecânica, Medicina e Reabilitação do Aparelho Locomotor, Ribeirão Preto, SP, Brazil

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ABSTRACT

The femoroacetabular impingement (FAI) is a condition recently characterized that results from the abnormal anatomic and functional relation between the proximal femur and the acetabular border, associated with repetitive movements, which lead labrum and acetabular cartilage injuries. Such alterations result from anatomical variations such as acetabular retroversion or decrease of the femoroacetabular offset. In addition, FAI may result from acquired conditions as malunited femoral neck fractures, or retroverted acetabulum after pelvic osteotomies. These anomalies lead to pathological femoroacetabular contact, which in turn create impact and shear forces during hip movements. As a result, there is early labrum injury and acetabulum cartilage degeneration. The diagnosis is based on the typical clinical findings and images. Treatment is based on the correction of the anatomic anomalies, labrum debridement or repair, and degenerate articular cartilage removal. However, the natural evolution of the condition, as well as the outcome from long-term treatment, demand a better understanding, mainly in the asymptomatic individuals.

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Impacto femoroacetabular

RESUMO

O impacto femoroacetabular (FAI) é condição de caracterização relativamente recente; decorre de relações anatômico-funcionais anormais entre a região proximal do fêmur e o acetábulo, associadas a movimentos de repetição, que acarretam lesões no labrum e na cartilagem acetabular. As alterações são representadas pela retroversão acetabular ou diminuição da altura entre a borda lateral da cabeça e o colo femoral. Além disso, o impacto femoroacetabular pode ser secundário a fraturas do colo do fêmur com consolidação viciosa ou decorrer de osteotomias pélvicas que provocam o retrodirecionamento do acetábulo. Essas anomalias levam ao contato femoroacetabular patológico que origina forças de impacto e cisalhamento durante os movimentos do quadril. Em consequência, há lesão labral e artrose precoce. O diagnóstico é feito pela sintomatologia típica, sinais

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[☆] Study conducted at the Department of Medicine, Biomechanics, and Locomotive Apparatus Rehabilitation, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP, Brazil.

E-mails: Volponjbvolpon@fmrp.usp.br, hc.ortopedia@gmail.com

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radiográficos e ressonância magnética. O tratamento fundamenta-se na correção das anomalias anatômicas, reparo do *labrum* e remoção da cartilagem lesada. Entretanto, há necessidade de conhecer melhor a evolução natural da afecção, principalmente nos indivíduos assintomáticos, bem como resultados do tratamento em longo prazo.

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Introduction

In the recent past, a group of young people, with or without history of previous affection of the hip, complained of pain in the inguinal region, during or after physical activities or after long sitting periods. Paradoxically, the physical examination was poor and the radiographs were interpreted as a normal aspect or, in some cases, presented alterations consistent with sequelae from previous illness, such as Legg-Perthes or slipped capital femoral epiphysis, but that did not explain the symptoms in the light of the knowledge at the time. As a result, there was no specific diagnosis and therapy; the recommendation was symptomatic treatment and restriction of physical activities. However, in some cases, there was long term evolution to articular degeneration,^{1,2} which was diagnosed as primary (or idiopathic) osteoarthritis. Nowadays, it is known that many of these people had the condition now termed femoroacetabular impingement (FAI). At first, it was only described based on clinical examination, plain radiographs, and surgical findings; currently, diagnosis is also based on magnetic resonance imaging and arthroscopic findings.³⁻⁶

The current concept is that FAI is a condition that results from the abnormal contact between the femoral head and the acetabular rim, which leads to a mechanical conflict that causes microtrauma to the acetabular labrum and cartilage, which in turn injures these structures.⁷ Usually, the impact is caused by changes in the head-neck junction and/or the acetabulum. However, it can occur in morphologically normal hips that are subjected to great physical demands associated with repeated flexion.^{8,9}

However, the notion of hip impingement is not new. One of the earliest references to this condition is attributed to Smith-Petersen,¹⁰ in 1936, who described it as a result of the femoral neck shock against the acetabulum and identified the causes as originating from femoral or acetabular changes. The observations that identified the cause of the pain as the mechanical conflict between the femoral neck and the edge of the acetabulum, which resulted in traumatic arthritis, are valid. That same author coined the term *impingement* to explain the pathophysiological mechanism; he presented a proposed treatment, whose foundations are still applied today.¹⁰ In 1965, Murray¹¹ identified cases of primary osteoarthritis associated with abnormal relationship between femoral head and neck, which he termed tilt deformity. Subsequently, the condition was thoroughly described by Harris.¹²

However, interest in the disease was renewed in 1991 by Ganz et al.,¹³ as a cause of hip pain and dysfunction. These authors showed that there was an association of pain and limited movement after viciously consolidated femoral neck

fractures. The radiographs showed, in the vicinity of the femoral neck, a bone protrusion that clashed against the anterior (two cases) or posterior portion of the acetabulum (four cases) during hip movement. Later, Strehl and Ganz¹⁴ added 11 cases with previous impingement, also due to fracture. Then, it was observed that the condition could occur in cases with no history of trauma, in people with overuse of the hip flexion movement due to sport or work.⁹

Currently, the concept of FAI is well established and its treatment has evolved significantly.^{1,2,15-17} Since then, the number of articles on the subject has grown exponentially.^{15,18} In recent years, the issue has been repeatedly addressed in the Brazilian Journal of Orthopedics.^{4,8,19-23}

Pathophysiology

The hip is a ball-and-socket joint, and its movements require bearing of the femoral head in the acetabulum. Impingement arises when the harmony of this movement is altered, which results in mechanical interlocking of the last degrees of the femoral head movements, which in turn makes this structure strike the lateral edge of the acetabulum, causing regional microtraumas. The most affected structures are the labrum and the anterolateral area of the articular cartilage of the acetabulum; the detrimental forces are represented by compression and shear.

In a normal hip, in addition to an adequate coverage of the femoral head by the acetabulum, the presence of the cervicocephalic offset is also important, i.e., the difference in height between the neck of the femur and the spherical edge of the femoral head (Fig. 1A). This gap is important, as it ensures the accommodation of the femoral neck to the periphery of the acetabulum, in order to provide the last degrees of movement (Fig. 1B). The reduction in the offset caused by loss of sphericity of the femoral head is caused by an anomalous extension of the proximal femoral epiphysis, mainly in the anterosuperior region (coxa recta).¹⁵ This extension can be a phylogenetic vestige²⁴ or arise as a response to excessive sporting activity during skeletal maturation.²⁵ In other cases, the etiology of FAI may be evident, such as in cases of femoral neck fracture sequelae,¹⁴ Perthes disease,²⁶ epiphysiolysis,²⁷ and coxa vara,⁹ among others.

The impact may arise when the offset is reduced, or even reversed, by the presence of a protuberance of the femoral neck, which will strike the edge of the acetabulum during flexion and internal rotation of the hip (Fig. 2A). This is known as the cam effect, which originates from the pistol grip deformity.^{9,22} In the case of small protrusions, the initial damage is primarily in the acetabular cartilage, causing abrasion

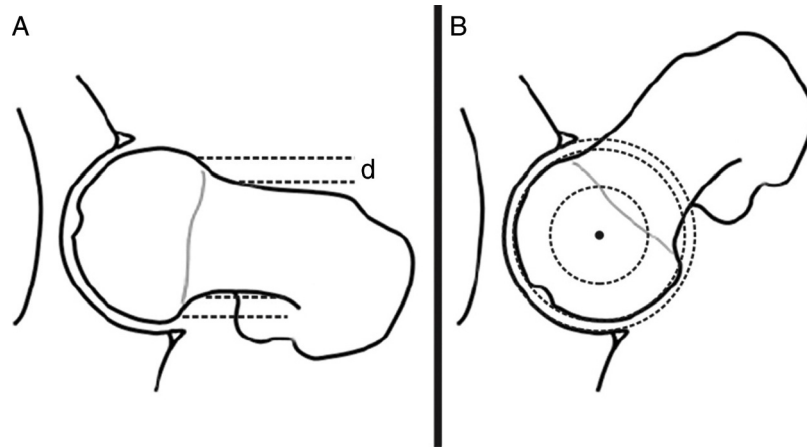


Fig. 1 – Illustration of the anatomical and functional features of the cervico-cephalic junction of the hip. (A) Femoral neck offset in relation to the free border of the femoral head (d). (B) Normal movements of the head in the acetabulum occur when the joint is concentric, i.e., there is a coincidence between the geometrical centers of the femoral head and acetabulum. This allows for a harmonic bearing of the femoral head within the acetabulum. The cervico-cephalic offset (d) allows for the extension in the last degrees of movement. (Drawing adapted from Emary²⁸).

or lamination, as the protruded portion penetrates into the acetabulum, shears the articular cartilage, and damages the labrum through the same mechanism.²⁸ Thus, most acetabular or labral chondral lesions due to cam impingement are located anterosuperiorly.^{1,2}

When abnormalities are predominantly acetabular, there is a pincer impingement (Fig. 2B).^{16,28,29} These changes result from cases with *coxa profunda* or *protrusio acetabuli*, wherein the femoral head is excessively contained in the acetabulum due to acetabular retroversion, which can be constitutional³⁰ or originate from pelvic osteotomies, such as Salter or triple osteotomy.³¹ There is also the less frequent possibility of excessive acetabular anteversion.

Finally, acetabular and femoral changes can coexist (mixed impact).⁵

Physical examination – diagnosis

FAI caused by alterations in the cephalocervical junction is more common among men aged 20–30 years.¹⁶ Conversely, impingement caused by acetabular changes is more often observed in middle-aged women.³²

Symptomatology

Pain in the hip region, whether anterior or posterior, may be a manifestation of a number of regional problems; for the correct diagnosis, a detailed history and semiological tests, as well as images, are paramount. Early diagnosis of FAI can be a challenge because many patients have insidious symptoms,

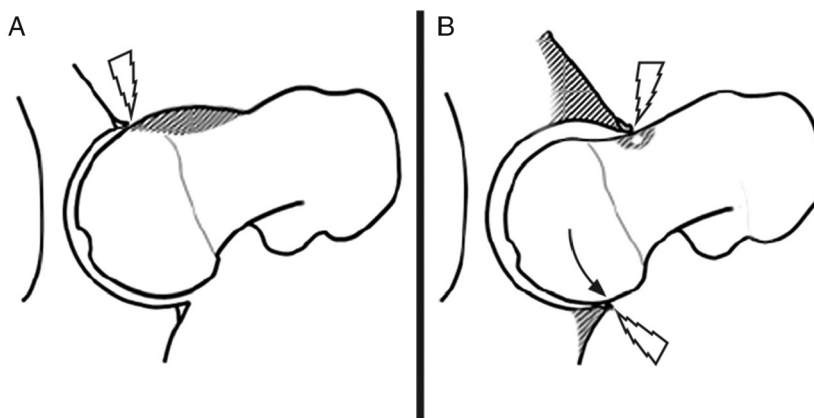


Fig. 2 – Illustration of the types of movement blocking in cases of femoroacetabular impact. (A) In the absence of cervico-cephalic offset, or its inversion, the femoral head strikes the lateral edge of the acetabulum in the last degrees of flexion movement, associated with internal rotation and/or adduction (cam impingement). (B) When the acetabulum is deep or retroverted, the femoral neck strikes the acetabular rim and causes injury to the labrum (pincer impingement). In sequence, by counter-movement, the femoral head is forced against the posterior edge of the acetabulum, which leads to an additional labral tear. (Drawing adapted from Emary²⁸).

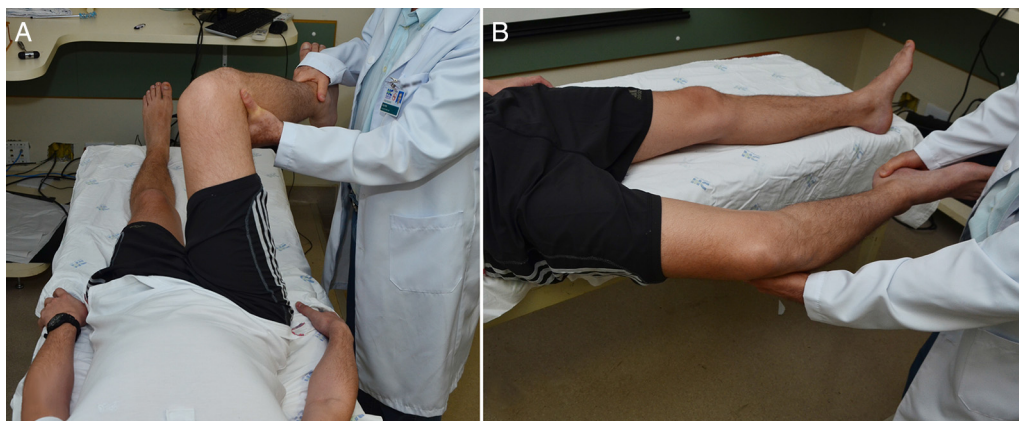


Fig. 3 – Clinical tests for impingement. (A) For the anterior impingement, the hip is flexed at 90°, adducted, and internally rotated. (B) For posterior impingement, the lower limb to be evaluated is placed outside of the examination table, extended, abducted, and externally rotated. Both maneuvers should trigger the patient’s usual pain.

radiographs that are apparently normal or have minor modifications, and symptoms can coexist with conditions of nearby structures.³³

An individual with anterior FAI would complain mainly of chronic pain in the groin area, with insidious onset, long-term, and progressive worsening. Acute exacerbations can occur when there are physical excesses. Patients are typically young adults,¹⁶ many of whom practice a sport that involves hip flexion.^{8,34} Pain may be constant, intermittent, or at rest, and may interfere with sleep, either preventing it or causing waking.

In addition to the classic symptoms in the groin, there may be an association with pain in the anterior thigh, the trochanteric region, and even on the inner face of the knee, triggered or worsened by physical activity involving hip flexion or sitting for extended periods.³³

A posterior impingement is manifested by pain in the gluteal, lumbosacral, or posterior region of the thigh,³³ associated with movements or positions in hip extension and abduction. However, when there is already secondary arthrosis in both posterior and anterior impingement, the pain becomes more severe, more typical of joint degeneration, and usually leads to the abandonment of physical activity.

On physical examination, thigh atrophy and a slight claudication may be observed. The last few degrees of motion of the hip are limited. The Trendelenburg test can be positive, and impingement tests are positive in 88.8% of cases.³³

An objective physical examination should investigate the involvement of various structures of the region. When pain is anterior, the following should be considered: inguinal hernia, iliopsoas bursitis, pubalgia, trochanteric bursitis, degeneration or rupture of the tendinous portion of the gluteus medius, and FAI. There is a positive association between inguinal hernia and FAI; the two conditions can coexist, especially in athletes.³⁵

To search for an anterior impingement, a test that reproduces it should be performed: the individual is placed in supine position and the affected hip is flexed at 90°, adducted at approximately 20°, and in this position, the internal rotation is done. For a positive test, pain normally experienced

by the patient should be reproduced (Fig. 3A).^{23,28} The overall movement of the hip is usually preserved, except in the last degrees of rotation and flexion. In cases of great impact, there is a greater limitation of flexion, which sometimes is only possible when associated with external rotation (Drehmann sign). In cases of arthrosis or acetabular protrusion, various movements may be significantly affected.

The subsequent impacts cause pain in the gluteal region; the differential diagnosis includes the most common conditions in this location, such as sacroiliac arthritis, sacral stress fracture, injury to the hamstring muscles, greater trochanteric pain syndrome, piriformis syndrome, ischial bursitis, ischiofemoral impingement, and chronic pelvic floor dysfunction.³⁶

The test for posterior impingement should be done with the hip in extension, slight abduction, and external rotation.²⁸ To facilitate these maneuvers, the lower limb to be tested should be placed, without support, out of the examination table (Fig. 3B).

Images

Morphological alterations of the proximal femur

Although plain radiographs do not show all cases of loss of sphericity of the femoral head, if several views are made, that possibility is reduced.

The most striking aspect of the femoral changes is the pistol grip deformity, which is synonymous with the loss of sphericity of the femoral head (*coxa recta*) and reduction of the cervico-cephalic offset. These anomalies can now be seen on the anteroposterior radiograph of the pelvis (Fig. 4A), with care to keep the hip in internal rotation at 15° to avoid false positives.²⁸

However, the neck profile is the most suitable position to view the neck-head junction (Fig. 4B). This can be achieved using the classical Lauenstein view (frog position) or the extended neck profile (Dunn view) at 45° or 90° of flexion (these are equivalent).³⁷ Dunn’s extended view can be replaced by the cross table view.³⁸ Generally, all these incidences are needed, with a choice of cross table and extended view.

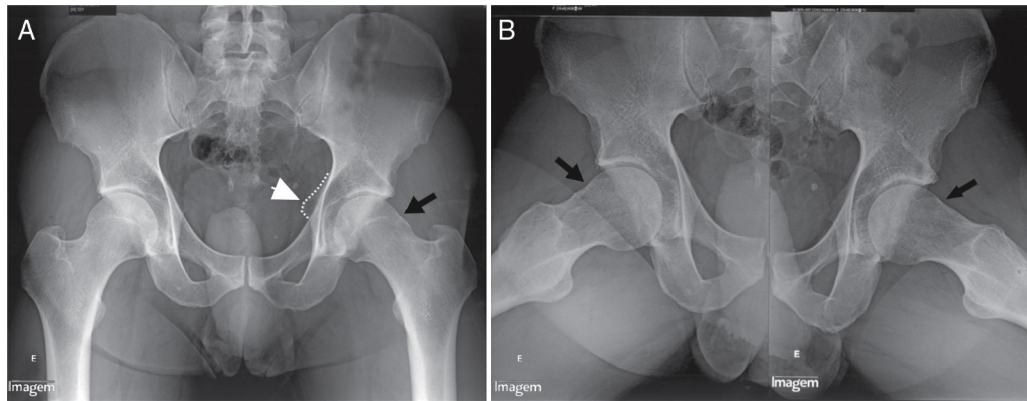


Fig. 4 – Alterations on hip X-rays in cases of femoroacetabular impact. (A) In the proximal region of the left femur, there is a typical pistol grip deformity, with rectification of the sphericity of the anterior portion of the femoral head (black arrow). In this radiograph there is a greater prominence of the ischial spine, which suggests an associated acetabular retroversion (white arrowhead). (B) The same patient on the Lauenstein view; this radiograph shows the decrease in the head-neck offset on both sides, with alterations that predispose to impingement (black arrows).

The cervico-cephalic offset can be assessed by measuring the Nötzli alpha angle³⁹; this angle was originally described for magnetic resonance imaging, but was adapted for radiographs in extended profile. This angle may vary with age, gender, and view, but it is generally considered to be normal when up to 50°. ³⁷ Fig. 5 shows the outline of that angle. The posterior angle, named beta, may be similarly traced. ⁴⁰

The completion of radiographic hip series is made using the false profile of Lequesne and Sèze, ⁴¹ used to visualize the anterosuperior region of the hip, a frequent site of initial joint degeneration. Some minor signs may be present, such as ossification of the acetabular rim and small cystic lesions in the cervix (cases of pincer impingement).

Acetabular alterations

Assessment of the acetabulum is made with anteroposterior hip radiographs. A well positioned pelvic radiograph implies, in addition to the symmetries of the iliac wing and obturator foramen, a distance of 2–3 cm from the projection of the coccyx to the pubic symphysis. ⁴² The anterior and posterior rims of the acetabulum, which should be divergent in the caudal direction, are identified. In cases of retroversion, these lines approximate and even intersect (cross-over sign; Fig. 6). ^{30,40} However, a false diagnosis may be obtained, due to the pelvic tilt. ⁴³ It is also possible to observe an excessive prominence of the ischial spine ⁴⁴ and asymmetry of the obturator foramen.

Coxa profunda and *protrusio acetabuli* can be quantified in the anteroposterior radiograph of the pelvis, by measuring the centrolateral angle of Wiberg. When this angle is above 40°, the hip is considered to be at risk of flexion impingement (Fig. 7A and B). ⁷ The excess coverage can be seen in the Lequesne and Sèze view, which allows for a good visualization of the anterior region of the femoral head, where the first joint degeneration arises.

Although computed tomography is able to assess the head-neck junction, it does not show the soft tissue and cartilage; furthermore, it implies a large radiation dose. Even in subtle bone changes in femoroacetabular junction, computed

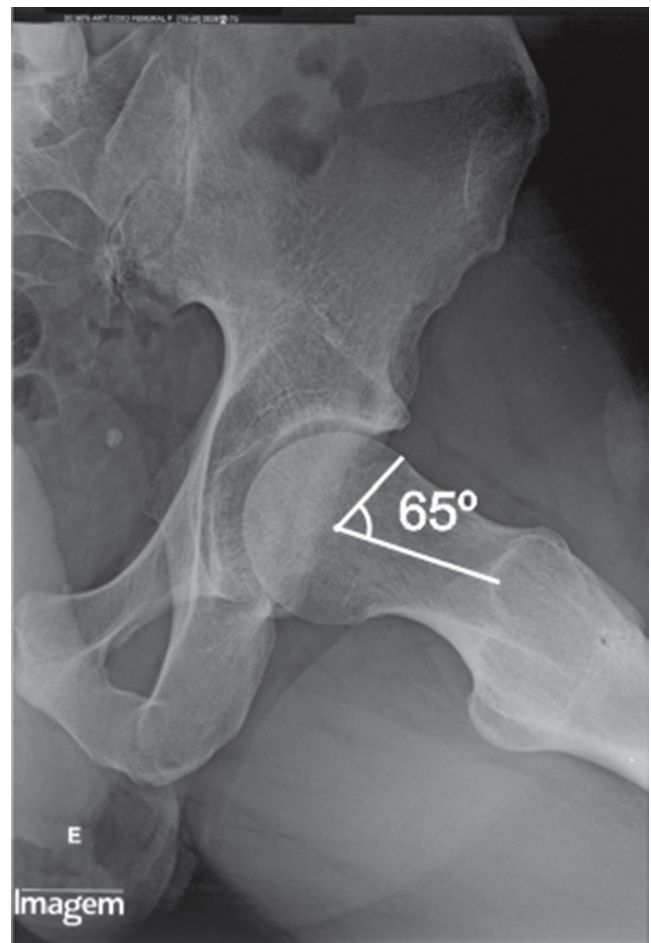


Fig. 5 – The same patient from the previous figure. Profile radiography of the femoral neck, with a measurement of the alpha angle. The center of the femoral head is determined. From this point, a line is drawn until the limit of the spherical portion of the femoral head and another line is drawn along the center of the neck. The angle between the two straight lines is the alpha angle (normal 50°).

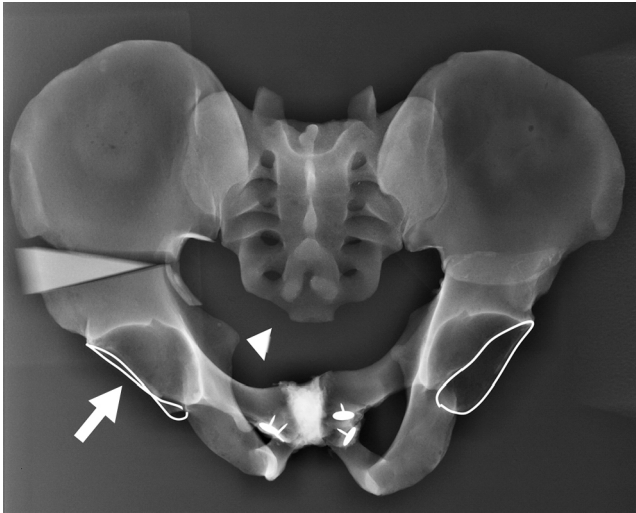


Fig. 6 – Radiography of a hip model with metal repairs to the acetabular rim. On the right side, a Salter osteotomy was simulated, with a 20° edge. Osteotomy causes retroversion of the acetabulum, which can be observed by the crossing of the anterior and posterior edges of the acetabulum (crossover sign; arrow), prominence of the ischial spine (arrowhead), and asymmetry of the obturator foramen.

tomography has intrinsic limitations.⁴⁵ Thus, it should not be used routinely to diagnose FAI. However, it is useful when it is important to quantify the acetabular version.⁴⁶

Magnetic resonance imaging with radial sequences has become valuable, as it shows the bone portion and the labrum in detail, allowing for accurately tracing the alpha angle.³⁹ It also assesses the sphericity of the femoral head and the articular cartilage.

The protocol indicates that images should be obtained along the head-neck axis at an interval of 10–30°. A normal labrum has a triangular aspect, defined margins, and low signal intensity on T1 and T2; it is continuous and inserted in the bone edge of the acetabulum, except for a small gap in

the anterior region of the acetabulum. A degenerated labrum shows increased signal in T2. Rupture is expressed as a high-signal linear band in the labrum or in the acetabular cartilage. In cases of chronic pincer impingement, local ossifications may be observed. Cartilage changes appear in regions adjacent to the labrum because there is continuity between the two structures.⁴⁷

Treatment

When symptoms are typical and diagnosis is confirmed by imaging exams, the consensus stipulates that an intervention should be made to prevent the onset or the progress of osteoarthritis.¹⁵ Treatments with manipulation (chiropractic) and physical therapy can worsen symptoms.²⁸ However, it is difficult to establish a treatment when arthritis is already advanced. In this condition, an arthroplasty should be considered, depending on the patient's profile, type of symptoms, and degree of disability. Nonetheless, a less aggressive surgical treatment, usually arthroscopic, with removal of the blockades, debridement or repair of the labrum, and joint debridement, can provide relief, especially in younger patients.

There is no consensus whether to treat asymptomatic patients based only on imaging exams⁴⁸ or those in whom asymptomatic isolated lesions of the labrum were detected.⁴⁹ The morphology of FAI corresponds to a set of diagnostic parameters based on static images, while FAI is a dynamic complex resulting from morphological changes associated with activities involving specific hip movements.⁵⁰ That is to say that many people have images suggestive of FAI but do not present any clinical symptoms.⁵¹

Surgical treatment

The principles of surgical treatment are to correct anatomical deformities, debride and/or reinsert the labrum, and remove the degenerated cartilage.²⁹ Surgical treatment usually provides good results.^{6,8,49,52}

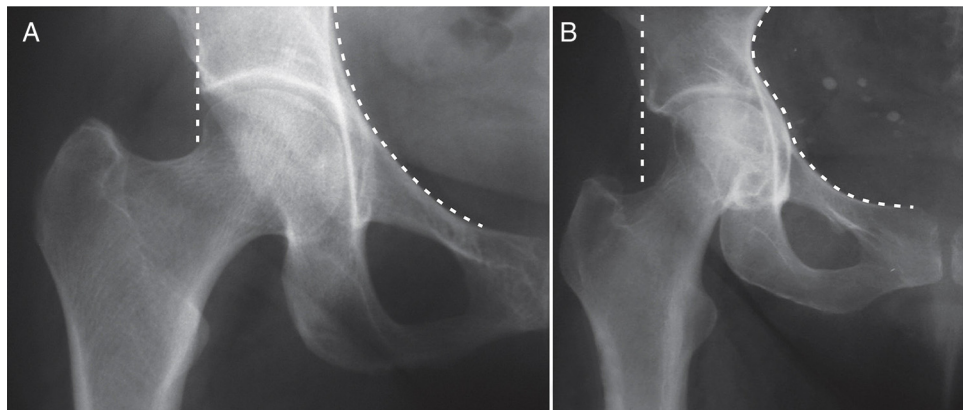


Fig. 7 – X-rays in cases of coxa profunda (A) and protrusio acetabula (B). In the latter case, the cephalic entrapment is more severe and there is a bulging in the iliopubic line.

Cam impingement

When the main deformity is *coxa vara* with secondary impingement, treatment is based on correction of the cervico-diaphyseal angle. This is usually enough to remove the neck from the impact region, but it is recommended to address the head-neck junction through the same surgical approach, and directly observe whether the impingement persists with a flexion-adduction-internal rotation hip maneuver. If so, the protruding portion should be removed.

When the impingement is caused primarily by a protuberance in the neck-head junction (*coxa recta*), the protruding part should be resected and the cervico-cephalic offset should be carved (chondro-osteoplasty). During the same surgery, repairs and/or debridement of the labrum and of articular cartilage are made. These procedures can be achieved by three main approaches: open access with hip dislocation, association of arthroscopy and mini-arthrotomy, and arthroscopy. The three methods are effective in improving pain and function, and are safe procedures.⁵²

Surgical hip dislocation

This technique was described by Ganz et al.^{13,53} and is considered the gold standard for the treatment of cam impingement. However, it presents major complications related to the femoral osteotomy,⁵² requiring training and experience. It allows approach for all pathological components present, with appropriate chondrocostal osteoplasty and debridement of the cartilage. However, this debridement should not be exaggerated, as the limit for neck thickness resection is 30%; if it is resected any more than that, a fracture may occur.⁵⁴ The labrum should be debrided and reinserted; this is important to its preservation, as it performs a sealing effect on the hip. When the labrum is unrecoverable or non-existent, reconstitution with substitutes such as fascia lata, knee flexors, or round ligament may be attempted,⁵⁵ but these techniques are considered experimental.

Arthroscopy and arthrotomy by anterior mini-access

In 2005, Clohisy and McLure²⁹ described the dual approach for cases of cam impingement. First, an arthroscopic inspection of the hip is made, followed by debridement of the articular cartilage and labrum, if necessary. After arthroscopy, through a small anterior incision, the Smith-Petersen space is deepened,¹⁰ the capsule is opened, and osteoplasty is performed. This technique gives results comparable to others, but it has significant incidence of injury to the lateral cutaneous nerve of the thigh.⁵² Moreover, as training in arthroscopy advances, the authors have tended to abandon open access.

Arthroscopic treatment

This method has been increasingly used, with success rates ranging from 67% to 90%.⁷ The correct approach of the alterations is made only arthroscopically, following the standard steps for this procedure.⁶ With practice and familiarity, it is possible to debride the labrum and articular cartilage, as well as remove excess bone, in order to recover the spherical shape of the femoral head (*coxa rotunda*). Complications are those common to hip arthroscopy and include injury of the lateral cutaneous nerve of the thigh and paresis of the sciatic nerve.

Pincer impingement

When the impact is predominantly caused by poor orientation of the acetabulum, this should be corrected through periacetabular osteotomy, which is a quite effective procedure,⁵⁶ but difficult to perform, and should be reserved for experienced professionals. The reports on the results using the technique are scarce, because in acetabular retroversion impingement the symptoms are delayed, so that when there is secondary osteoarthritis, treatment is performed through arthroplasty.

Final considerations

FAI is a well-defined clinical entity in which there are morphological alterations, whether constitutional or acquired, associated with repetitive movements of the hip; these can lead to injury of the labrum and acetabular cartilage with subsequent arthrosis. The symptoms manifest as pain and movement limitation, which progressively worsen, and the effective treatment is surgical correction of anatomical abnormalities. However, more studies are needed to better define the population at risk, those who should be treated, and what is the best approach in terms of treatment.⁵² Thus, larger follow-up periods are necessary not only to evaluate results, but also to better understand the natural course of the disease.

Conflicts of interest

The authors declare no conflicts of interest.

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