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Review article

General principles for treatment of femoral head fractures

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ABSTRACT

Femoral head fractures occur almost exclusively as a result of a traumatic hip dislocation. Treatment is typically an emergency and includes the reduction of the dislocated hip under anesthesia. As a rule, the earlier the reduction, the better the outcome. Open reduction and internal fixation of the fracture of the femoral head is the treatment of choice for most young patients. In some selected cases when there is a very small fragment located in the region below the fovea, removal should be indicated. In elderly patients and those who experience severe femoral head impaction, it is preferable to perform a total hip replacement. Despite optimal management, the rate of complications after femoral head fractures may reach as high as 50%. In the present study, the authors review the general principles of management of patients with femoral head fractures.

1. Introduction

Femoral head fractures occur almost exclusively as a result of a traumatic hip dislocation.[1,2] Due to the intrinsic anatomical stability of the hip, most of these injuries result from high-energy trauma, typically in the form of automobile accidents (such as collisions and pedestrians being run over) or falls from a significant height. Approximately two thirds of patients are young adults and associated injuries are extremely common, occurring in as many as 75% of the cases.[1]

Treatment is typically an emergency surgery that includes the reduction of the dislocated hip under anesthesia.[1,2] In most cases, it also includes the fixation or removal of the fractured fragment of the femoral head. As a rule, the earlier the reduction, the better the outcome.[3,4] Worse outcomes have been observed when the hip is reduced incongruently or more than six hours after the injury, mainly due to the statistically significant increase in the rate of avascular necrosis of the femoral head.[1–4]

Treatment outcomes tend to be inconsistent, largely because of the fracture's frequent association with pain, joint stiffness, and loss of function. Complications that are most commonly seen after femoral head fractures are osteonecrosis (ON), osteoarthritis (OA) and heterotopic ossification (HO).[5,6]

In the present study, the authors review the general principles of management of patients with femoral head fractures.

2. Initial assessment and treatment

In the first assessment of a patient with a femoral head fracture, the possibility of high-energy trauma should always be considered. Thus, the series of priorities in hospital care and the adoption of life-saving measures and maneuvers should come before the specific approach used to address the hip injury, even if a dislocation is detected during the initial treatment period.[1–4] However, it is important to remember that the existence of a dislocated hip is an orthopedic emergency, and that the joint should be reduced as soon as the patient's clinical condition is stable enough. The delay in a correct diagnosis and, as a consequence, the delayed reduction of the joint, increases the risk of complications at the site.[1–4]

The presence of ipsilateral fractures in the affected segment is a potentially complicating factor; this diagnosis must be discarded or confirmed as early as possible.[3,4] In addition to the possibility of an associated fracture of the acetabulum or the proximal femur, femoral shaft, knee (which are more common), and foot and ankle (which are less frequent) injuries are also seen in patients suffering from a femoral head fracture. The existence of an ipsilateral

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fracture of the femoral shaft, for example, leads not only to potential systemic consequences resulting from heavy bleeding and the massive release of fat emboli into the blood, but can also clinically mask hip dislocation and delay reduction.

Unless the patient is unable to cooperate, a careful neurovascular examination of the affected limb should be performed before the hip is reduced. Traumatic injury of the sciatic nerve may occur after traumatic posterior hip dislocation, usually affecting the peroneal division.[7]

The AP radiographic view of the pelvis, which is taken in the patient's acute hospitalization phase or during their secondary assessment, can clearly reveal the existence of a dislocated hip in most cases. A dislocated femoral head is incongruent with the acetabular cavity and is usually smaller and more cranial than the contralateral side. In addition to the position of the lower leg (particularly in terms of rotation), visualization of the lesser trochanter provides another clue as to the direction of the dislocation. In this phase of patient care, other radiographic views are not usually necessary unless an ipsilateral fracture in the segment is suspected, as this fracture may require a change in the dislocated hip reduction maneuver used.

It is important to remember, however, that an impaction fracture, very small fragments of the head, and intra-articular free bodies can be difficult to diagnose using conventional radiology alone. This factor makes the CT scan an indispensable part of the imaging assessment. Osteochondral fractures caused by impact on the femoral head identified with a CT scan have been reported in approximately 63% of cases after a posterior hip dislocation and between 12% and 100% of cases after an anterior hip dislocation.[8] McCarthy and Busconi observed free fragments within the joint that went undiagnosed by conventional radiography in 76% of cases of traumatic hip dislocation in which an arthroscopy was performed.[8]

Different joint reduction techniques have been described in the literature over the years.[1–4,9,10] Most report that closed reduction must be attempted first in a surgical environment with the patient under general anesthesia. Most of the maneuvers used today are based on longitudinal traction in line with the position of the affected leg. Heroic attempts at reduction without anesthesia and outside the appropriate setting should be avoided at all costs.

We prefer to use the Allis' maneuver both for posterior on anterior hip dislocation. For posterior dislocations, the patient is placed in supine position on the operating table, preferably with the pelvis away from anything that would hinder the post-reduction radioscopic view. When longitudinal traction is applied, the assistant's hands stabilize the patient's pelvis, and the existing deformities are gradually corrected.[1–4] In some cases, a second assistant is required to perform counter traction, especially when the patient is very muscular or obese (Fig. 1).

More recently, new maneuvers have been described in the literature. Hendey and Avila presented a modification of the Lefkowitz maneuver, which had originally been meant to reduce hip prosthesis posterior dislocations, referred to as the Captain Morgan technique because of its similarity to the character's pose on the label of the alcoholic beverage.[9] Schafer and Anglen presented a technique called the East Baltimore Lift maneuver, also for the reduction of a posterior dislocation of the hip.[10] Other techniques described in the literature, such as Bigelow's maneuver and the gravity method of Stimson, are being used less frequently given the fact that, in most cases of traumatic hip dislocation, the reduction can be achieved using any of the aforementioned maneuvers after sufficient muscle relaxation.[1–4]

After the reduction, the hip should be scanned in detail through imaging exams, and the femoral head fracture should be classified so that appropriate treatment can be provided.[11] As a rule, because femoral head fractures represent a joint injury, non-surgical treatment can be only considered for select cases of femoral head fractures classified as Pipkin Type 1, in which the bone fragment deviation or diastasis is less than 1.0 mm.[12] The hip must be concentrically reduced and stable to allow for early joint mobility free of load. The use of skeletal traction to keep the hip in place is not justified as a definitive method of treatment because it creates the risk of chondrolysis through the decrease in the volume of synovial fluid.

3. Definitive treatment of femoral head fracture

A nonconcentric hip reduction either caused by an intra-articular free body or an associated fracture of the femoral neck should be seen as a failed reduction, since an increase in pressure on the articular cartilage occurs. Skeletal traction is frequently used while the patient is waiting for surgery; however, there is no evidence of its validity in terms of its ability to decrease chondral damage.[1,2,13] Marecek and Routt have described a percutaneous technique for the removal of intra-articular bone fragments located in the weight-bearing area of the hip using a hook and fluoroscopy to guide it.[13] The patient is placed in the supine position with enough longitudinal skeletal traction to open a small space between the femoral head and the acetabular roof. A small incision is made lateral to the hip at level and in line with the acetabular roof in order to introduce the hook. The fluoroscopy is directed to the hip through the capsular defect produced by the dislocation. The fragments are manipulated so that they can be withdrawn from the hip loading area, preferably outside the joint through the same capsular space, thus allowing for a concentric reduction. While the technique is quite interesting, its use is rarely indicated and, once again, it requires a deep understanding of the anatomy in this region.

Another option is the arthroscopic removal of intra-articular fragments in the hip.[14,15] In theory, hip arthroscopy offers advantages in terms of arthrotomy, particularly in cases in which the fragments are too small or fragmented and their fixation is not possible. Less blood loss, a shorter operating time, and improved cosmetic appeal can be considered to be some of the advantages of the technique. Its rate of complications is low — it ranges from 1% to 6%.[14,15] The most common complication is peripheral

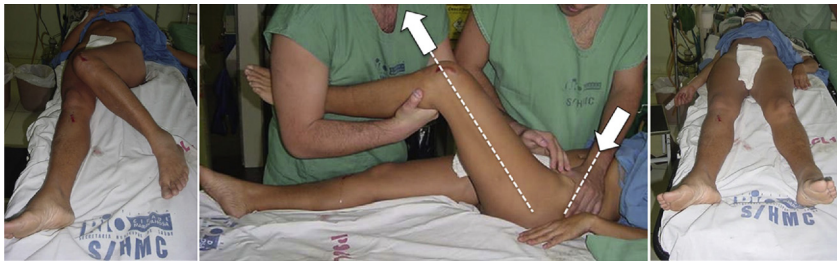

Fig. 1. Allis' maneuver for the reduction of a posterior hip dislocation. Note the bruise over the left knee – dashboard injury.

neurological injury caused indirectly by traction or directly by the surgical instruments (affecting the pudendal nerve, the lateral cutaneous nerve of the thigh, the sciatic nerve, and the femoral nerve). Other complications include bruising at and bleeding from the portals, swelling of scrotum and labia majora, abdominal compartment syndrome resulting from fluid leakage through the acetabulum, chondral damage, and ON of the femoral head.[14–16]

Open reduction is preferable whenever there is a nonconcentric hip reduction (Fig. 2).[6,11,17] This reduces the risk of additional trauma, thus avoiding abrasion to the articular cartilage and bone contusion at the head of the femur. The surgeon who performs open reduction must be fully familiar with the surgical anatomy of the hip and must be aware of the fixation techniques used on fractures in this region.[18]

In young patients with Pipkin types I and II fracture, in which the hip is congruous after reduction and the fragment is anterior or anterolateral, it is preferable to use either the Hueter anterior approach (the vertical incision of the Smith-Petersen approach) or the Watson-Jones anterolateral approach.[6,11,17,19] In some cases, especially when the Watson-Jones approach is used, the hip must be moved to allow for perfect visualization of the interfragmentary reduction (Fig. 3). When the head fragment is posterior or there is an associated fracture of the posterior rim of the acetabulum (Pipkin type IV), a limited posterior Kocher-Langenbeck approach with digastric trochanteric osteotomy is preferable.[20]

The fragment can be fixed both with 3.0-mm headless screws or mini fragment screws and small-fragment metal screws, taking care to countersink the head of the implant into the articular cartilage.[6,11,17,19,21] The joint capsule should be always repaired.

When femoral head impaction is present and the patient is young, the goal is to save the femoral head. In this situation it is preferable to use a limited posterior Kocher-Langenbeck approach with digastric trochanteric osteotomy to perform the controlled dislocation of the hip. The articular cartilage in the area of impaction must be lifted and the subchondral defect filled with autogenous bone graft in a technique very similar to the "trapdoor" procedure for ON of the femoral head.[22] Bone graft is normally taken from the greater trochanter since it is already open due to the osteotomy. After grafting, the cartilage is returned to its original position and closed using isolated sutures and 4.0 non-absorbable sutures. The hip is reduced and the osteotomy is fixed with two extra-long small-fragment cortical screws without washers (Fig. 4).

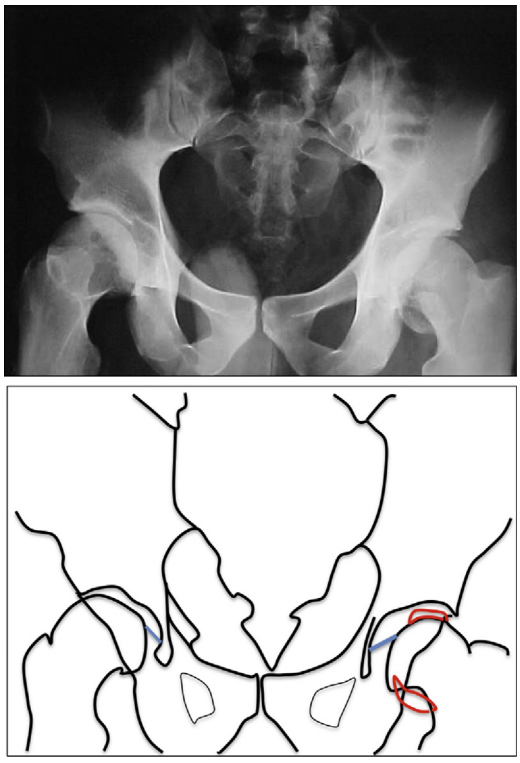

Fig. 2. AP radiograph of the pelvic ring and schematic representation of this radiographic image. Note the presence of intra-articular fragments (red) and the increased distance between the femoral head and Köhler's teardrop to the left compared to the opposite hip (blue lines).

In young patients with Pipkin type III fractures, the goal is to save the femoral head. Therefore, the most important measure that should be performed in the acute phase is the reduction and fixation of the femoral neck fracture. The anterior Hueter approach is advisable with percutaneous fixation of the neck using a lateral stab incision. If the femoral head fracture is visible when this approach is used, it should be immediately fixed; if not, its fixation can be performed in another time using the same protocol described previously for Pipkin types I and II fractures. In this specific type of fracture (Pipkin type III), the use of a posterior approach must be avoided due to the higher risk of increased vascular damage to the femoral head.[23]

In patients with a Pipkin type IV fracture, the pattern of the acetabular fracture will determine the choice of approach. When there is greater involvement of the posterior component, it is preferable to choose for a limited posterior Kocher-Langenbeck approach with digastric trochanteric osteotomy. With the hip dislocated, the femoral head should be fixed first. When there is greater involvement of the anterior component, the anterior ilioinguinal approach or, in certain cases (fragmentation of the quadrilateral plate), the anterior intrapelvic approach (so-called modified Stoppa approach) is preferable.

In elderly patients and those who experience femoral head impaction, it is better to perform a primary total hip replacement.[6,11,17,19,23] When there is an acetabulum fracture, sometimes it is necessary either to perform reduction and fixation of the posterior column or to use a reinforcement cage.[24] When there is a defect on the bottom of the acetabulum, autogenous bone graft both with thin slices and chips of the femoral head is extremely useful (Fig. 5).

The choice for bearing surface materials, sizes, and fixation techniques basically depends on both the degree of functional independence and the surgeon's preference. It is important to have in mind that the prosthesis should outlast the remaining lifetime of the patient and should be easy to revise if it fails.[25] Metal-on-metal and ceramic-on-ceramic bearings have lower wear rates and larger heads should be more difficult to dislocate but may have higher volumetric wear.[25] However, for most of this population, a cemented total hip arthroplasty (THA) with metal-on-polyethylene bearing seems to be a good option. Hemiarthroplasty is reserved to patients with limited functional demand when there is no associated fracture of the acetabulum and no symptomatic degenerative hip disease.

Figs. 6 and 7 show the algorithm for the management of femoral head fractures in young and elderly patients, respectively.

4. Postoperative protocol

Immediate postoperative CT scans have become increasingly common to check for the quality of the reduction, intra-articular free fragments undetected during the surgical procedure, and articular hardware penetration, particularly in Pipkin type IV cases.

The rehabilitation protocol should be initiated as soon as possible. Optimal pain control is mandatory and must include regular administration of oral and intravenous opioids.[26] Partial weight bearing should begin immediately with a pair of crutches or

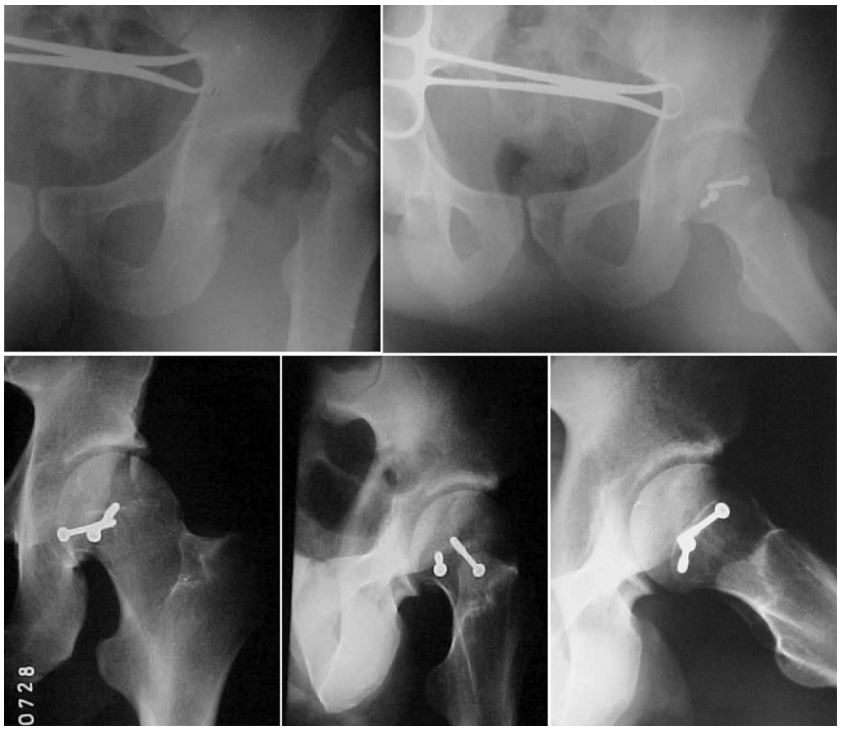

Fig. 3. Intraoperative dislocation of the left hip using the Watson-Jones approach for reduction and fixation of the femoral head fracture under direct vision.

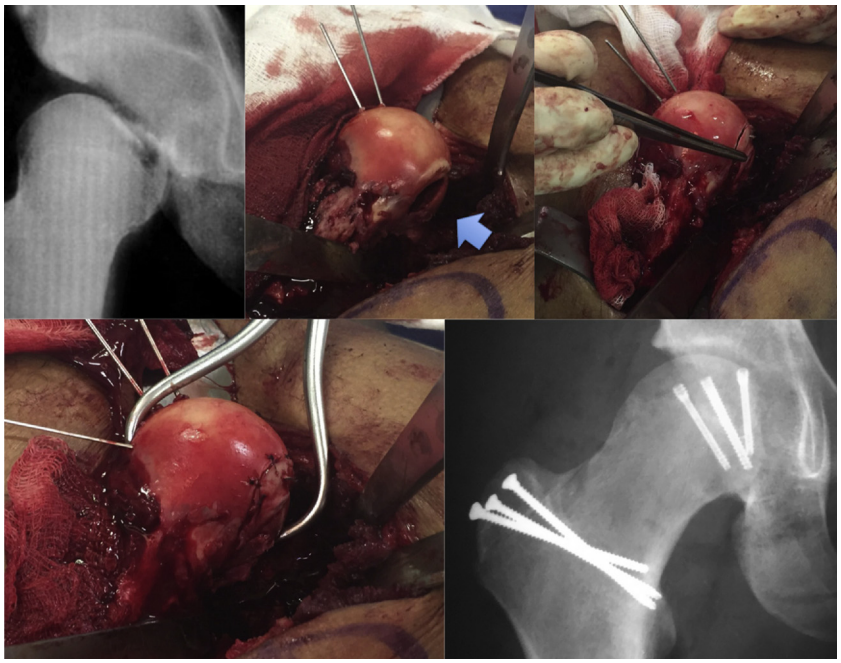

Fig. 4. Fracture caused by impaction of the femoral head and treated using elevation and grafting of the subchondral defect and fixation with small-fragment cortical screws. Blue arrow shows the impaction of the right femoral head. Note the sequential elevation of hyaline cartilage, the subchondral defects filled with autologous cancellous bone, and chondral sutures with non-absorbable sutures.

a walker and progress gradually until the fracture is healed and total weight bearing is allowed. Restriction in flexion, adduction, and internal rotation of the hip is advisable for the first two months when a THA is performed through a posterior approach.

Clinical and radiological outpatient evaluation should be taken in the first, second, third, sixth and twelfth postoperative weeks. Radiographs include AP and Judet views of the affected hip.[1,2]

It is important to inform the patient and his or her relatives that regardless of the treatment performed the rate of complications and poor outcomes after femoral head fractures may reach as high as 50%.[5,6,11,23] The main complications after femoral head fracture are ON, OA, and HO. Other complications such as irreversible damage to the sciatic nerve, pain, and loss of hip joint mobility due to chondrolysis also occur, albeit less frequently. Some factors have

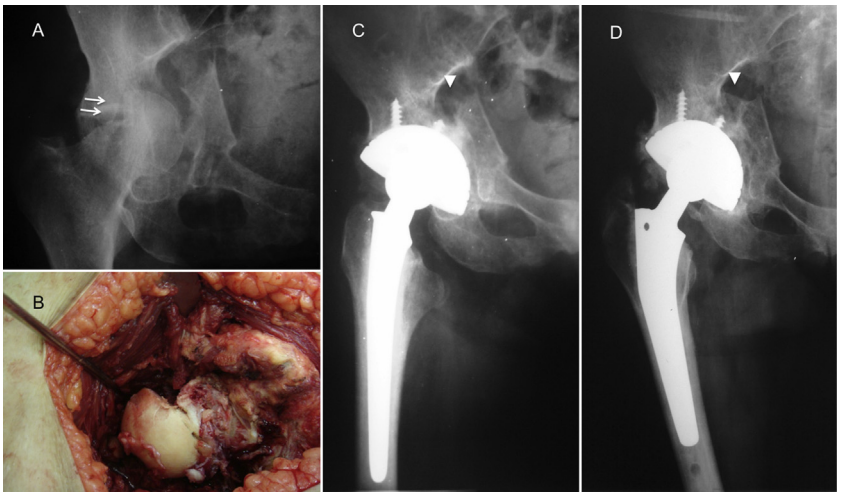

Fig. 5. Femoral head impaction fracture associated with a fracture of the anterior column of the acetabulum in a 76-year-old female patient. A – Preoperative AP view of the right hip shows the femoral head fracture (arrows) and the acetabular fracture; B – Intraoperative image demonstrates the large impaction area of the femoral head; C – AP view of the right hip three months after surgery (note the grafted area with femoral head cylinders) (arrowhead); D – AP view of the right hip 12 months after surgery shows complete osseointegration of the bone graft (arrowhead).

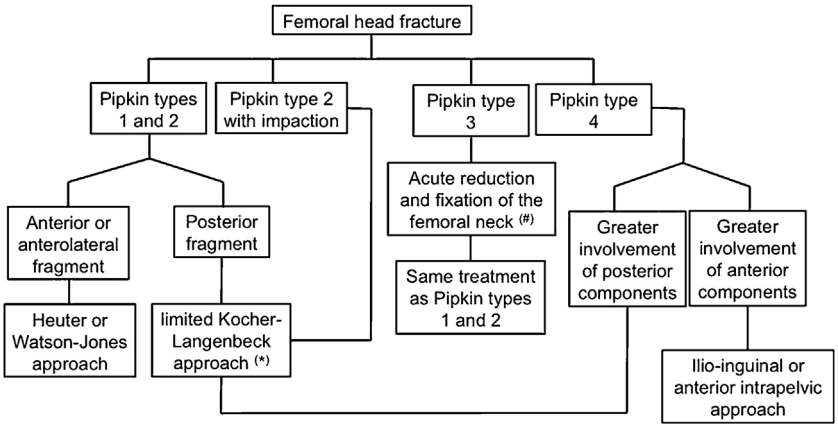

Fig. 6. Example flow chart showing the algorithm for the treatment of femoral head fractures for young patients. (*) Limited posterior Kocher-Langenbeck approach with digastric trochanteric osteotomy. (#) Authors recommend the use of the anterior Hueter approach with percutaneous fixation of the neck using a lateral stab incision.

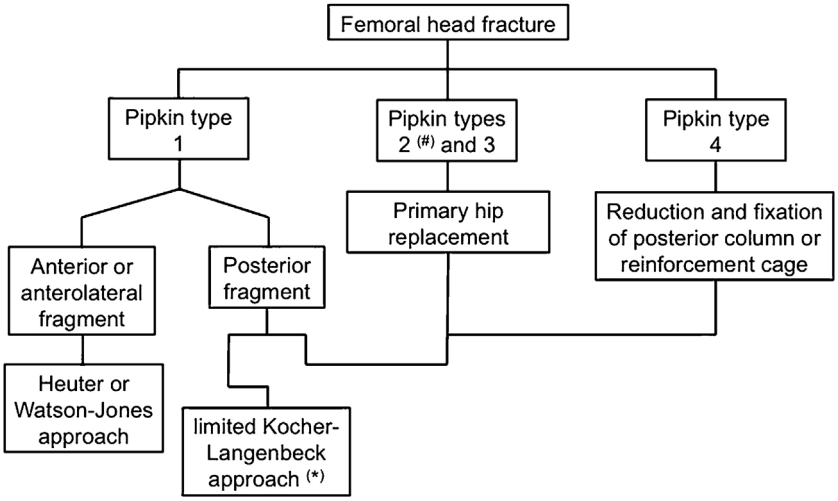

Fig. 7. Example flow chart showing the algorithm for the treatment of femoral head fractures for elderly patients. (*) Limited posterior Kocher-Langenbeck approach with digastric trochanteric osteotomy. (#) Pipkin type 2 with or without head impaction.

been directly correlated with the final outcome. The amount of damage to the articular cartilage of the femoral head is the main factor used to measure the poor outcomes observed in patients who have experienced a femoral head fracture after traumatic hip dislocation. The time taken to reduce the hip dislocation, the number of maneuvers performed to congruently reduce the hip, and the fracture pattern are other factors that have been directly or indirectly associated with the success of treatment of these patients. Overall, Pipkin types I and II fracture have better outcomes than types III and IV. The lack of uniformity in outcome assessment, however, significantly hinders the stratification of these risk factors and generates uncertainty in terms of variables that depend on the surgeon, such as the reduction maneuver.

Conflict of interest

The authors have no conflict of interest.

Auth**ors' contributions**

VG designed the review. VG, MG, and RCG drafted the first version of the manuscript. FSS, PT, MML, and HAK contributed to revisions of the manuscript. All authors read and approved the final version of the manuscript.

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