Open Surgical Treatment of FAI: Safe Surgical Dislocation of the Femoral Head

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Introduction

Femoroacetabular impingement (FAI) has been proposed as a one of the major causes of osteoarthritis of the hip [2, 10, 11]. Although term such as "head tilt" or "pistol grip" deformities have been introduced previously [5, 14, 28, 31], FAI, as a unique biomechanical process, has only recently been proposed [11]. FAI is a dynamic phenomenon causing chondro-labral damage as a consequence of repetitive hip motion. Impingement results from structural abnormalities including reduced anterolateral femoral head-neck offset, an overcoverage of the anterosuperior acetabular rim or an excessively deep acetabulum. During flexion and internal rotation [8, 11, 29], these abnormalities can produce mechanical impingement of the femoral head against either the acetabular labrum and/or its adjacent cartilage [2, 15, 19, 20, 21, 35, 44]. With time, this repetitive trauma leads to further reduced joint clearance and eventually to early osteoarthritis [3, 10, 24, 30, 42, 43].

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Based on the osseous deformities present, two distinct types of FAI have been identified, cam and pincer FAI (Fig. 9.1a–d) [11, 16, 17, 18, 37, 38, 39]. These morphological variations are not mutually exclusive. It is common for patients to have combined picture of both cam and pincer FAI [2].

Surgical indications for open treatment of FAI include but are not limited to groin pain and impingement exam findings, impingement osseous abnormalities on imaging, and prearthritic hip disease (Tonnis scale <1). Other indications include large deformities not amenable to arthroscopic treatment and failed arthroscopic treatment. An important factor to consider is the type, magnitude, and location of underlying osseous abnormality. Although arthroscopy is an emerging technique in the treatment of FAI, it is technically challenging and has its limitations. Arthroscopy can easily handle the secondary effects of the morphological abnormality (chondro-labral pathology), while there is as yet no consensus as to how well it can handle the underlying osseous abnormalities [40]. On the other hand, a surgical dislocation provides complete visualization of the acetabular and femoral surfaces, allowing identification of chondral lesions on the labrum surface. In addition, structural morphological changes such as lack of anterior femoral neck offset and acetabular overcoverage can be addressed with relative ease [9, 26, 33, 41]. In addition, failure to address the underlying bony abnormality is likely to lead to continued symptoms, progressive joint degeneration, and poor outcomes [23, 34]. There are relative few contraindications with the open technique such as extensive arthritic changes (Tonnis scale ≥2) and significant acetabular protrusio or dysplasia.

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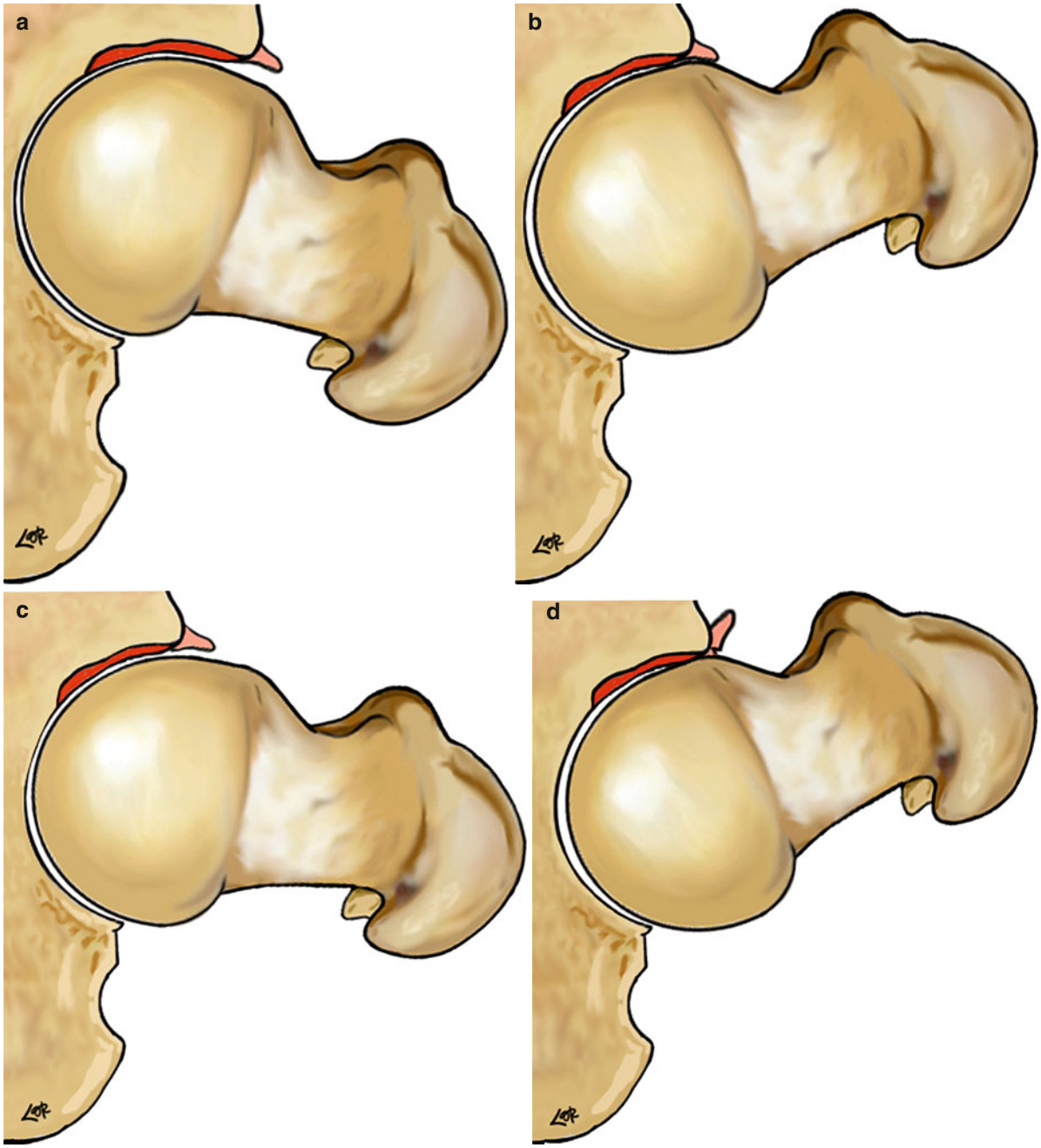

Fig. 9.1 The two forms of FAI are shown. Cam FAI occurs when the lack of offset on the femoral neck (**a**) leads to mainly anterior damage (*arrow*) through repetitive trauma between the femoral neck and acetabulum during hip flexion (**b**). Pincer FAI occurs secondary to acetabular overcoverage (**c**) causing anterior abutment and subsequent "contrecoup" injury to the cartilage of the posteroinferior acetabulum (*arrows*) during hip flexion (**d**)

Nonoperative Treatment

The treatment regime should be tailored to the patient. In most cases, conservative treatment is attempted first. These modalities include activity modification, rest, NSAIDs, and most importantly, a physical therapy regimen focusing on abdominal, lower back, and hip flexor strengthening. On occasion, intra-articular

injections can be used for both diagnostic and therapeutic purposes. We do not routinely perform intra-articular hip injections, except in selected cases where the origin of a patient's symptoms remains unclear. In many cases, conservative management strategies may only partially alleviate symptoms and often only mask symptoms. Attempts by physical therapists to improve passive range of motion are not often beneficial and may be counterproductive since limitation of internal rotation in FAI is due to abnormal osseous morphology. While some patients can temporarily benefits from these conservative measures, young athletic patients have difficulties to comply with activity modification.

Background of Surgical Technique

The key to a safe surgical dislocation is an in-depth understanding of the blood supply to the femoral head [12]. Studies dating back more than 40 years [36] as well as a recent cadaveric hips injection study have demonstrated that the medial femoral circumflex artery (MFCA) is the main blood supply to the femoral head [12]. The vessel crosses the obturator externus posteriorly; thereafter, it passes anteriorly to the short external rotators before perforating the joint capsule at the level of superior gemellus. The study also demonstrated that the vessel remained protected even during controlled surgical dislocation, provided that the external rotators and obturator externus remained intact. Unfortunately, the commonly utilized posterior approach requires division of the short external rotators and, doing so, violates the blood supply. As a result of this, a technique allowing a wide operative exposure and a safe surgical dislocation of the femoral head was developed [9]. The general concept of the technique is an anterior dislocation of the femoral head from a postero(lateral) approach. The short external rotators, and thus the MFCA, are left intact, while the joint capsule is exposed anteriorly by a trochanteric flip osteotomy.

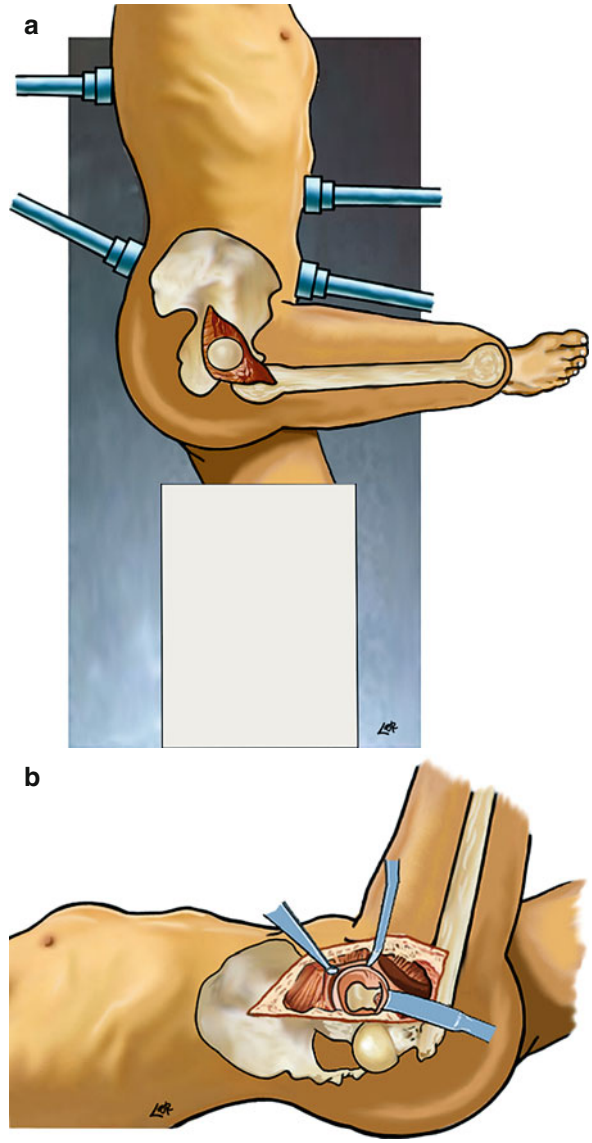

Fig. 9.2 Lateral decubitus position for surgical hip dislocation (**a**). This technique with exposure of the entire femoral head and acetabulum allows identification and treatment of FAI. In flexion/external rotation, the femoral head can be dislocated allowing nearly circumferential inspection of the entire acetabulum (**b**)

Technique

General or spinal anesthesia is used. The patient is placed in the lateral decubitus positions in well-padded bolsters. Correct orientation is important to allow accurate assessment of acetabular orientation during the procedure. The skin is cleansed with a standard preparation over the trochanteric region. The patient is prepped and draped in standard sterile fashion (Fig. 9.2a) with a free leg sterile bag drape on the opposite side of the operating table to receive the lower leg during hip dislocation (Fig. 9.2b). A second generation cephalosporin antibiotic is given for prophylaxis and continued for 24 h.

A straight lateral incision of approximately 20–25 cm in length is made along the anterior third of the femur which is continued proximal to the trochanteric tip. As a general rule, the more the adipose tissue, the longer the incision required for the trochanteric osteotomy. The fascia lata is incised in line with the incision and extended proximally without any violation of gluteus maximus fibers as described by Gibson [13]. The advantage of this approach is that the gluteus maximus muscle is not split, avoiding damage to the muscle and its anterior neurovascular supply.

The next step is to incise the trochanteric bursa. The innominate tubercle and the border of the vastus lateralis origin are now visible. By careful, superficial exposure of the posterior margin of gluteus medius, the posterocranial tip of the trochanter with the tendinous insertions of the gluteus medius can be seen and palpated. The small trochanteric branch of the MFCA can be identified running anteriorly along the posterior border of the trochanteric crest and should be cauterized. The trochanteric flip osteotomy can now be performed.

Ideally, the osteotomy fragment should provide continuity between the gluteus medius and minimus (specifically the long tendon anteriorly) proximally and the vastus lateralis via the osteotomy fragment distally. Thus, the osteotomy is not a digastric trochanteric osteotomy but actually trigastric in nature [25]. Conversely, the piriformis and short external rotators should remain attached to the nonosteotomized femur (stable trochanter). If done properly, the osteotomy should undercut the tendinous origin of vastus lateralis distally and leave a few remaining gluteus medius fibers proximally at the trochanter. This will increase the certainty that most of the underlying piriformis muscle tendon will remain on the stable trochanter. More recently, a step osteotomy has been used which improves reduction and primary stability of the trochanteric osteotomy.

To expose the posterior border of gluteus medius and trochanter, the limb should be internally rotated 20–30°. The osteotomy is performed with an oscillating saw roughly at an angle parallel to the internally rotated lower extremity. The osteotomy should run from the posterosuperior border of the greater trochanter distally toward the posterior border of the vastus lateralis muscle and remain parallel with the long axis of the femoral shaft. Although the osteotomy was originally described as a single plane cut, we would now recommend the use of a "triplanar" osteotomy to increase the mechanical stability of the osteotomy fragment, especially in older patients who may have compromised bone. The osteotomy consists of two broad chevron-type cuts leaving a step of 5 mm between them. Moreover, the osteotomy should not perforate the anterior cortex of the trochanteric crest, but rather leave it incomplete until an osteotome is used to lever the fragment forward for a controlled fracture. The advantage of this triplanar osteotomy is its increased stability on multiple planes and the relative ease to refix the fragment anatomically at the end of the procedure.

The osteotomy fragment is then mobilized. An 18-mm Hohmann retractor is placed in the osteotomy site, and the fragment is retracted and mobilized anteriorly. The mobile osteotomy fragment is in continuity with the gluteus medius and vastus lateralis. The fibers of the vastus lateralis origin at the posterior femur are gradually released to mid height of the gluteus maximus tendon. The mobile fragment can now be tilted more anteriorly, especially after the anterolateral part of vastus lateralis has been released subperiosteally from the femur with the hip in external rotation, flexion, and abduction. Proximally, the residual tendon insertions of the gluteus medius, still attached to the stable part of the trochanter, are cut. After releasing these fibers, the piriformis tendon becomes visible. Ideally, a portion of the piriformis tendon should be attached to the mobile osteotomy fragment. These residual piriformis fibers on the mobile fragment are then released to further mobilize the osteotomy fragment.

The next step is to develop and expose the hip capsule between the interval of gluteus minimus and the piriformis. The limb is placed in extension and internal rotation. The interval between the gluteus minimus and the posterior capsule is carefully dissected posteriorly down to the acetabular rim. This interval offers the greatest certainty that the blood supply to the femoral head will be preserved. Furthermore, the constant anastomosis between the inferior gluteal artery and the deep branch of the medial circumflex artery is optimally protected. It runs along the lower margin of the piriformis tendon and is of fundamental importance because it alone can guarantee vascularization of the femoral head if there is injury to the deep branch [12]. Finally, the limb is placed in abduction, flexion, and external rotation again; the anterosuperior capsular insertions of the gluteus minimus muscle are then released while preserving the attachment of the long tendon to the mobile fragment. After gradual release of the posterior, superior, and anterior insertions of gluteus minimus from the capsule, the hip capsule is

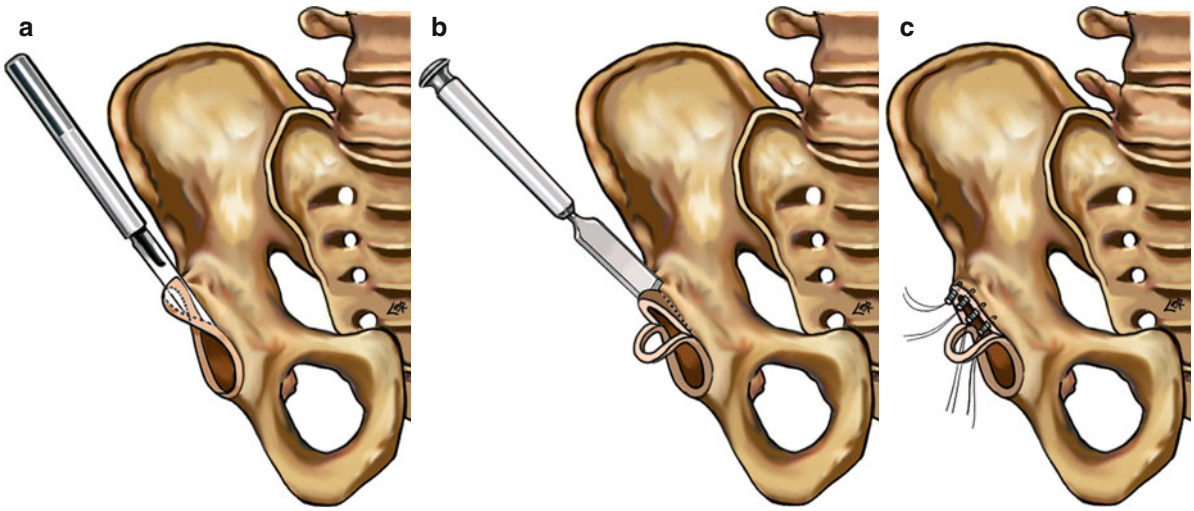

Fig. 9.3 Resection of excessive anterior rim (**a**) in acetabular retroversion with a curved osteotome (**b**) can be performed after labral detachment as part of the approach to the acetabular rim. After sufficient rim resection, (**c**) labral refixation is performed with bone anchors

completely exposed; however, the short external rotators must always remain protected and attached to the stable trochanter.

With the hip capsule completely exposed, a z-shaped capsulotomy (right hip) is performed. This begins with a linear incision along the line of the femoral neck close to the superior border of the stable trochanter. The capsulotomy then runs posterosuperiorly along the acetabular rim inside out in a proximal direction to avoid injury to the retinaculum, cartilage, and labrum. Finally, an inferomedial extension of the capsulotomy is performed over the front of the anterior capsule in the direction of the lesser trochanter. The labrum and chondral surfaces are also best preserved by an "inside-out" arthrotomy which allows for adequate visualization at all times.

The next critical step is careful dislocation of the femoral head and appropriate positioning of the retractors to visualize the pathology. First, an 8-mm Hohmann hook is hammered into the bone below the capsular margin but above the labrum and holds the soft tissues back at the 12 o'clock position. A Langenbeck hook may also be adequate for this purpose. A bone hook is then placed around the femoral calcar, and hip is gently subluxed with traction, flexion, and external rotation as the limb is prepared to be placed into the sterile leg bag. The ligamentum teres, which is preventing complete dislocation, is then cut with parametrium scissors taking care not to damage the chondral surfaces of the acetabulum or femoral head. On rare occasions, the hip is only subluxed, and all operative work is done in this position. The lower extremity is then dislocated anteriorly and placed in the sterile leg bag. Two additional retractors are placed: one at the anterior acetabular rim and the other inferiorly by the transverse acetabular ligament. A 360° view is now possible of the entire acetabulum. Posterior retractors can also be placed if necessary. Finally, a bump is placed on the femur (slight abduction), and a posterior force is applied to the femur by an assistant for further acetabular visualization.

The hip can now be inspected for evidence of injury secondary to femoroacetabular impingement. Open inspection initially begins with capsulotomy when the amount of synovial effusion and the degree of synovitis are documented. Next, attention turns to the acetabular chondro-labral surfaces. As soon as the cartilage is exposed, it should be protected from drying out with a constant trickle of saline solution. Damage to the acetabular cartilage and labrum is documented. A blunt probe can be used to examine the labrum for detachments or tears; the cartilage must be assessed for softening or delamination. By altering the position of the leg in flexion, all articular surfaces can be visualized and any chondro-labral injuries in both the anterosuperior and posterosuperior regions documented. If labral tears are irreparable, then the labrum is debrided. Likewise, grade four contained chondral lesions are often microfractured.

If pincer impingement is noted preoperatively and confirmed intraoperatively, then acetabular rim trimming is performed (Fig. 9.3). First, the labrum must be

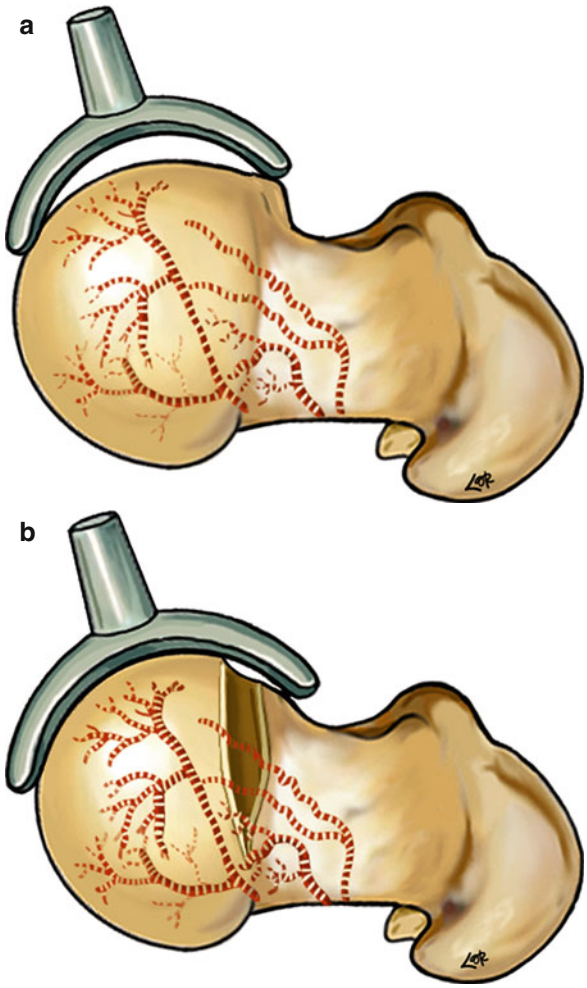

Fig. 9.4 Resection osteoplasty of the femoral head/neck junction can be used to recreate the normal concave contour of the femoral neck. (**a**) Transparent templates are used to determine femoral head sphericity. (**b**) Femoral osteochondroplasty is performed to repair the insufficient offset

detached from the acetabular rim by sharp dissection. If there is a full-thickness chondral defect, then a microfracture is performed. Since the typical location for acetabular rim lesions is the anterosuperior margin, the excess rim segment can be removed with a curved osteotome. The amount of rim resected depends on the location of the cross-over sign and the value of the lateral center-edge angle seen on the preoperative plain film. Additionally, intraoperative impingement tests are performed to assess the degree of overcoverage causing impingement. Rim excision is performed until no impingement exists but not at the expense of creating instability or dysplasia. Following rim resection, the labrum is reattached by driving two to four small mini G2 suture anchors (Mitek Surgical Products, Westwood, MA) into a bed of bleeding cancellous bone approximately 5–10 mm apart [6]. At this moment, the sutures are only placed through the labrum; tightening is postponed until the femoral head is repositioned into the socket. This allows a more homogeneous expansion of the labrum over the head contour.

Next, attention turns to the femoral side. The retractors are gently removed, and the knee is lowered; the femoral head can be elevated out of the wound so that there is excellent visualization of the proximal femur. First, the posterosuperior retinaculum and vessels are identified and protected. Next, the sphericity of the femoral head can now be assessed after two blunt retractors are placed under the femoral neck. Nonsphericity is tested using appropriately sized transparent spherical templates. With these templates, a safe resection is predictable and the risk of femoral neck fracture is minimized [22]. The commonest location for this pathology is the anterosuperior head/neck junction, with the abnormal cartilage having a slightly hypervascular, pink appearance. The presence of a cyst near the peripheral border of the non-spherical segment is sometimes noted, which indicates the point of maximum impingement.

The abnormal bone can be removed carefully using curved chisels until a normal head/neck offset is recreated, taking great care not to injure the terminal branches of the MFCA in the posterosuperior retinaculum (Fig. 9.4a). Unfortunately, this area may also be non-spherical, in which case, the debridement should start proximally on the neck and reach the point where the vessels enter their intraosseous course. A periosteal elevator may also be used to strip a portion of the retinaculum off the bone as well. Femoral resection should be done cautiously with regular reassessment using the spherical templates to avoid overresection, which would not only increase the risk of femoral neck fracture (with excessive resection) but also endanger the loss of the labrum's suction seal effect with the femoral head.

Prior to relocation, the ligamentum teres is debrided. Perfusion should be confirmed by bleeding from the fovea and a raw cancellous surface created following neck debridement. Bone wax can be applied to the debrided surface prior to relocation. Hip relocation can be achieved with simple traction and controlled internal rotation, with care not to avulse the labral sutures. Following relocation, the sutures are tightened, and the range of movement is assessed to look for any residual impingement prior to closure.

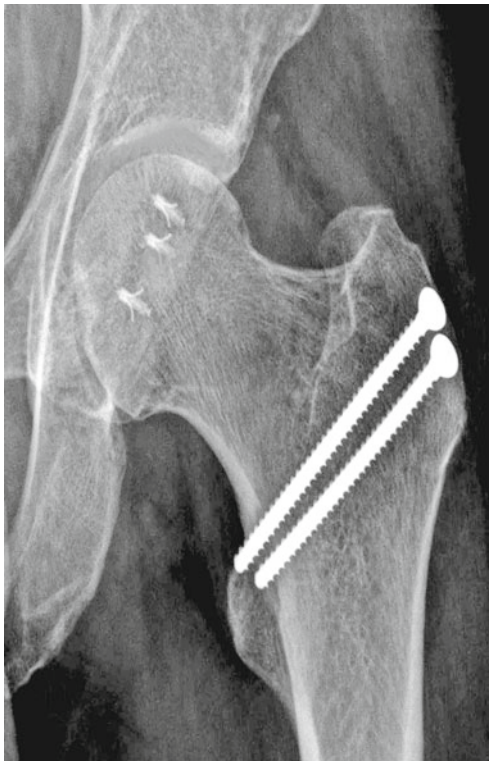

Fig. 9.5 Postoperative radiograph showing surgical dislocation through a transtrochanteric approach with acetabular rim trimming, labral refixation, and femoral offset correction

Capsular closure is done without excessive tension to avoid compression of the retinacular vessels. The trochanteric fragment is reduced anatomically according to the triplanar osteotomy cuts and reattached using 3.5- or 4.5-mm screws. With the triplanar trochanteric osteotomy, 3.5-mm screws are sufficient. On the other hand, 4.5-mm screws are much easier to remove if they become symptomatic. The fascia lata, fat, and cutaneous layers are carefully closed in a layered fashion. Drains are rarely indicated.

Postoperative Management and Rehabilitation

A postoperative radiograph is obtained in the recovery room (Fig. 9.5). The patient is usually immobilized postoperatively on crutches with toe-touch weight-bearing for a total 6–8 weeks. The patient is prohibited from hip flexion >70° and from actively abducting the extremity to allow proper healing of the osteotomy site. Continuous passive motion (with flexion limited to 70°) is started on postoperative day number one until discharge in order to prevent formation of intra-articular adhesions. If a microfracture was performed, then continuous passive motion use must be prolonged a total of 6–8 weeks. The patient is usually discharged after 5–7 days. All patients receive low-molecular-weight heparin until full mobilization occurs.

If after 8 weeks, radiographs show evidence of healing of the osteotomy site, then weight-bearing and motion restrictions are lifted. If there is any doubt, then therapy should be postponed for another 3–4 weeks. Full activities are allowed once the patient has regained full motion and strength, which usually requires 3 months.

Results

A review of the literature and results of open impingement surgery is presented in Table 9.1. To date, there have been approximately eight series with approximately 200 patients [1, 3, 4, 7, 23, 27, 32]. Prognosis generally depends on the extent of articular damage [1, 3, 4, 7, 23, 27, 32]. In other words, the extent of preoperative arthritis is an important predictor of outcome. In addition, labral refixation appears to yield better clinical and radiographic results, while cases with combined impingement and instability have had poorer results.

Complications

General complications such as infection, blood loss, and venous thrombosis are quite rare. Specific complications to this procedure include iatrogenic osteonecrosis, osteotomy nonunion, symptomatic hardware, under/over correction, and femoral neck fracture.

Although the risk of osteonecrosis exists, in numerous series, no instances have been reported [1, 3, 4, 7, 23, 27, 32]. A thorough understanding of the course of the medial femoral circumflex artery helps prevent this potential complication. Similarly, all these reports mention minimal trochanter fixation problems. If trochanter pseudoarthrosis does develop, then repeat stable osteosynthesis is recommended. With the new triplane osteotomy, trochanter nonunions have been almost eliminated. On the other hand, symptomatic hardware is not infrequent. If present, it takes a small outpatient procedure to

Table 9.1 Open clinical results of surgical dislocation for FAI

Paper	Hips	F/U	Impingement type	Other	Complications	Results
Beaule et al. [1]	37		Cam		No revisions or AVN, 9 ROH	Improvement in WOMAC, UCLA, and SF-12. 6/34 dissatisfied
Bizzini et al. [4]	5	2.7 years	Combined	Professional hockey players	None	All retuned to hockey
May et al. [23]	5	16.3 months	Cam	After arthroscopic labral debridement	None	Good
Peters and Erickson [32]	30	2 years	Combined	Worse results with worse pre-op arthritis	None	8 hips had progressive DJD. 4 got THA. 2 had staged PAOs
Espinosa et al. [7]	60	2 years	Combined	Labral refixation had less arthrosis	None	80% of labral refixation vs. 28% of labral resection had good/excellent
Beck et al. [3]	19	4.7	Combined	Worse results with worse pre-op arthritis	No AVN	5 patients THA, while 13 hips rated good/excellent
Murphy et al. [27]	23	2–12 years	Combined	Worse results with pre-op arthritis and combined impingement and instability	None	7 went on to THA, 1 had arthroscopic labral debridement
Tanzer et al. [45]	10	26 months	Cam	Technique was not with surgical dislocation but cheilectomy	None reported	HHS improved to 90, no reoperations

remove the hardware with minimal disability associated with it. Finally, under/over correction are also rare problems that can be eliminated with proper preoperative radiographic assessment in conjunction with carefully performed intraoperative impingement testing. Likewise, femoral neck fractures can be avoided with the use of templates to avoid excessive resections [22].

Conclusion

Open treatment of femoroacetabular impingement with surgical dislocation provides the surgeon with numerous advantages. First, it is a safe and extensile exposure of the hip joint. Second, a surgical dislocation provides the surgeon with the ability to evaluate all of the pathology under direct visualization. Finally, a surgical dislocation is a versatile procedure since it enables the surgeon to perform numerous impingement procedures from one exposure. Elimination of femoroacetabular impingement significantly improves patients' symptoms, and with further study, chondral disease may be delayed or prevented. At present, the best results are seen in patients with early chondral disease.

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