5 Open Femoral Osteochondroplasty and Rim Trimming

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5.1 Introduction

The goal of the treatment of femoroacetabular impingement (FAI) is to remove the pathomechanic femoral and/or acetabular deformities and to repair the injured labrum to restore normal function of the hip. The technique of safe surgical dislocation of the hip has been described more than 15 years ago [1] and was considered the gold standard for the treatment of intra-articular hip pathology [2]. Since the mid-2000s, hip arthroscopy became progressively more popular for FAI treatment. Bozic et al. [3] reported over 600% increase of hip arthroscopy between 2006 and 2010. The euphoria was dampened to some extent with the increase of revision surgery, mainly required for insufficient resection or unrecognized codeformities [4, 5].

Open treatment is the method of choice when the deformity is complex or more than one deformity is present. Examples are (1) global acetabular overcoverage as seen in coxa profunda, (2) severe acetabular retroversion, (3) combination with femoral retroversion, and (4) high riding greater trochanter. Severe femoral retrotilt as seen in Slipped Capital Femoral Epiphysis or complex deformities of the head as in Perthes disease are also indications for open surgery as is the hip after failed arthroscopic surgery. Prerequisite in any case is a comprehensive preoperative evaluation, often including magnetic resonance imaging (MRI) to check the cartilage condition and computed tomography (CT) for eventual axial deformities.

5.2 Surgical Dislocation of the Hip

General or spinal anesthesia can be used although general anesthesia is preferred for the possibility of muscle relaxation.

The patient is placed in lateral decubitus position with well-padded bolster. The anterior support, traditionally used for total hip arthroplasty, could interfere with free leg positioning when it is placed in the bag on the anterior side during hip dislocation. Instead, a single anterior squared pubic support is preferred (Fig. 5.1).

The trochanteric region is prepped and draped in a standard sterile fashion with the leg mobile. A sterile bag is hung on the edge of the table, anteriorly to the patient, to receive the lower leg during hip dislocation.

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Fig. 5.1 Patient positioned in lateral decubitus with a single anterior support against the symphysis. As such it does not interfere with the various leg positions allowing optimal access to all areas of the joint

Both Kocher-Langenbeck and Gibson approach could be used [1]. With the straight Gibson approach, the gluteus maximus muscle is not split and the scar becomes aesthetically better with less "saddleback deformation" of the subcutaneous tissues [6]. The skin incision is made along the anterior third of the greater trochanter, while the hip is fully extended (Fig. 5.2). With larger fatty layer, it is advantageous to make a cephalad extension of the skin incision; it facilitates the positioning of the oscillating saw for the trochanteric osteotomy [7]. The fascia lata is incised in line with the skin incision and at the level of the perforating vessels. The gluteus maximus is not split but retracted posteriorly, thus avoiding neurovascular damage to the anterior muscle's fibers [8].

The leg is then internally rotated to expose the posterior border of gluteus medius. At this moment, no attempts should be made to mobilize the gluteus medius and to identify the tendon of piriformis [1].

The trochanteric branch of the deep branch of the medial femoral circumflex artery (MFCA) can be identified after incision of the gliding tissue or a trochanteric bursa. This branch serves as a landmark to identify the superior border of the quadratus femoris, area where the deep branch of the MFCA runs as a posterior sling around the obturator externus tendon [9]. This trochanteric branch can be cauterized at the level of the planned trochanteric osteotomy without jeopardizing the vascular supply of the femoral head [7].

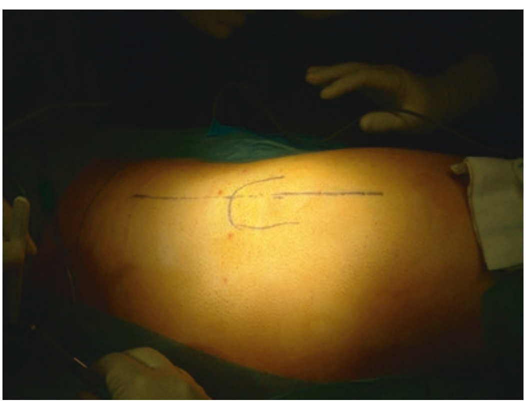

Fig. 5.2 The straight incision for Gibson's approach. It is less invasive than the Kocher-Langenbeck approach and usually provides an aesthetically better result of the contour of the thigh

Keeping the leg internally rotated of 20°–30°, the trochanteric osteotomy can be performed. The fragment provides continuity between gluteus medius/minimus proximally and vastus lateralis distally. All external rotators should remain on the stable part of the greater trochanter.

In the original description of the surgical technique, a straight trochanteric osteotomy was reported [1] (Fig. 5.3). The osteotomy line runs anterior to the posterior trochanteric crest with a proximal exit in the middle of the trochanteric tip. Doing so, some fibers of the gluteus medius insertion remain on the mobile fragment and have to be cut during mobilization of the fragment. However, it helps to keep the piriformis insertion on the stable part of the trochanter [1, 6]. The oscillating saw should not exit the anterior cortex of the trochanter; it can be broken by levering the fragment with an osteotome. With this technique, all external rotators remain attached to the stable part of the trochanter, allowing to preserve the deep branch of MFCA, which becomes intracapsular at the level of superior gemellus muscle [1].

With a step osteotomy one can achieve a more stable fixation of the fragment reducing the risk of trochanteric malunion and nonunion [10]. The

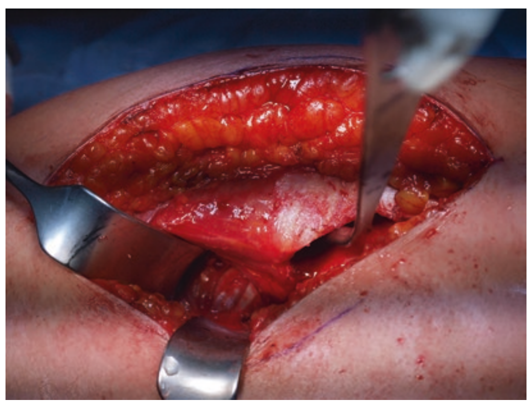

Fig. 5.3 The straight osteotomy of the greater trochanter as described in the original surgical technique. A straight line from the posterior edge of the greater trochanter to the posterior border of the ridge of vastus lateralis. The osteotomy is performed parallel to the long axis of the femoral shaft and should exit just anteriorly to the most posterior insertion of gluteus medius. Few fibers of the gluteus medius had to be left attached to the stable part of the femur and subsequently released

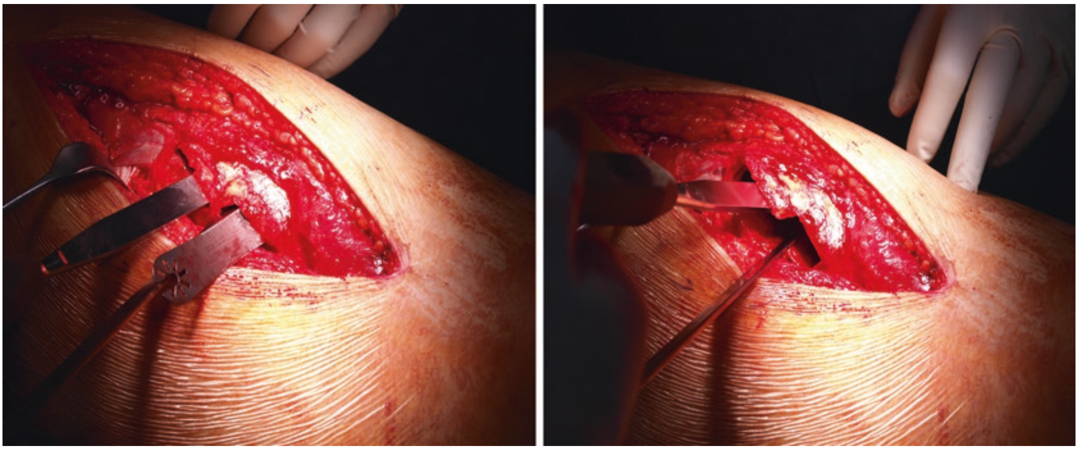

Fig. 5.4 "Z" osteotomy of the greater trochanter

step between the two surfaces should be about 5 mm [7] (Fig. 5.4).

A straight osteotomy is indicated when distal advancement of the trochanter is necessary. In cases without advancement, we prefer a step- or Z-osteotomy, although it is technically more demanding.

The osteotomized fragment can now be mobilized anteriorly with an Hohmann retractor. For sufficient mobilization, strong fibrous connections at the anterosuperior circumference have to be cut. Additional release of the long tendon of the gluteus minimus tendon is necessary only in cases of substantial trochanter advancement and will be done just before refixation. If a portion of the piriformis tendon remains attached to the mobile fragment, these fibers are cut closed to the trochanteric fragment. The fragment can now be tilted and completely mobilized anteriorly.

The safe interval to start the development of the capsule is between piriformis tendon and gluteus minimus muscle. The limb is placed in slight flexion and external rotation. The best way to find the interval is to start very close to the stable trochanter. All vessels and anastomoses to the femoral head are distal to the piriformis. The gluteus minimus muscle is dissected from the capsule and retracted cranially. Caution had to be taken to avoid damage to the piriformis. The integrity of the tendon of piriformis ensures protection to the sciatic nerve, which passes below to the piriformis muscle into the pelvis and to the anastomosis between the inferior gluteal artery and the deep branch of the medial circumflex artery. This anastomosis runs along the lower margin of the piriformis tendon and it alone can guarantee sufficient vascularization to the femoral head also in cases of injury to the deep branch [9, 11].

Complete exposure of the capsule is facilitated in different positions of the leg in flexion–extension as well as internal and external rotation. Usually a Z capsulotomy is performed for the right hip and an inverse Z capsulotomy for the left hip [1]. The first incision runs anterolaterally along the axis of the neck. Proximally the capsulotomy is extended posteriorly parallel to the acetabular rim until the retracted tendon of the piriformis. An inside-out incision helps to avoid damage to the labrum and to the articular surfaces. The anterior branch of the capsulotomy starts close to the anterior femoral insertion of the capsule and is directed towards the anteroinferior border of the acetabulum (Fig. 5.5).

The hip can now be dislocated. A Langenbeck retractor is used to keep the soft tissues back at the 12 o'clock position. The hip is gently subluxed with traction, flexion and external rotation, while a bone hook is placed around the calcar to help the dislocation. The ligamentum teres is then cut and the complete anterior dislocation is achieved with further flexion and external rotation. The leg is than placed in the sterile bag anteriorly to the patient. In cases of scarring from previous surgery or trauma, sciatic nerve inspection and dissection had to be performed before

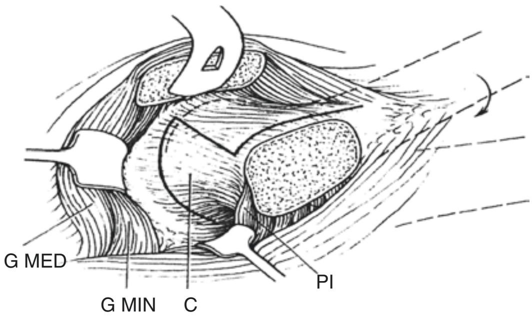

Fig. 5.5 Z-capsulotomy. The first incision runs anterolaterally along femoral neck; proximally it is extended posteriorly parallel to the acetabular rim; and distally it is extended anteriorly towards the lesser trochanter

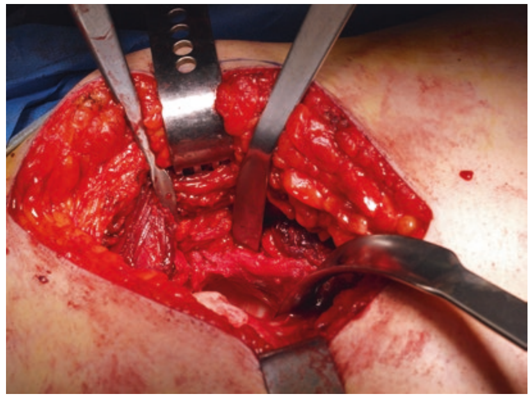

Fig. 5.6 Position of the retractors for acetabular exposure. One retractor at the 12 o'clock, one retractor anteriorly at the acetabular rim and a large, narrow, curved Hohmann retractor posteriorly to the acetabular rim and against the femoral neck

complete dislocation of the hip to avoid injuries to the nerve [1]. With relocation of the hip after the complete dislocation, areas of impingement could be identified during a complete range of motion in flexion–extension and combined movement of flexion–abduction–external rotation (FABER test) and flexion–adduction–internal rotation (FADIR test/impingement test). The posteroinferior rim area can be inspected with full extension and external rotation.

Complete 360° view and access to the acetabulum and nearly 360° to the proximal femur are now possible by manipulating the lower limb.

As soon as the hip is dislocated and the cartilage is fully exposed, it should be protected from drying out with frequent washes with saline solution [6, 7].

5.3 Acetabulum

For the evaluation of the acetabulum, two additional retractors are used: one anteriorly at the acetabular rim and the other inferiorly, just caudal to the transverse acetabular ligament. The thigh is held parallel to the ground while the assistant pushes against the knee for further exposure of the acetabulum. If the acetabular exposure is still not optimal, a small, Hohmann retractor placed on the superior acetabular rim can retract the neck offering better exposure of the posterior rim area (Fig. 5.6). To present the posterior rim area, the leg is taken out of the bag and the hip is extended to release the posterior muscle flap and the sciatic nerve. A small Hohmann placed posterior to the posterior rim pushes the neck away allowing inspection of the posteroinferior joint.

The pattern of damage to the acetabular cartilage and labrum depends on the morphology of the hip [12]. In cam or inclusive impingement, the cartilage is usually damaged in the anterosuperior area of the acetabulum (1 o'clock position). In an early stage of the disease, the labrum usually is stable and not injured while the cartilage is separated from the labrum towards the center of acetabular socket. In later stages, the labrum becomes also part of the degeneration. Instead, in pincer or impacting impingement, the damaging force hits first the labrum. The typical damage pattern is ganglion formation within the labrum and degeneration of a small area of adjacent cartilage. In retroverted hips the area is anterosuperior, and in deep sockets it can be circumferential [7, 12]. In a later stage the labrum can be found torn. Repeated microtrauma can induce bone apposition at the base of the labrum worsening further the impingement [13].

If flexion is enforced, the pressure between the posteroinferior femoral head and acetabulum increases developing subluxation and also a contrecoup lesion on both femoral head and acetabular cartilage [7, 12].

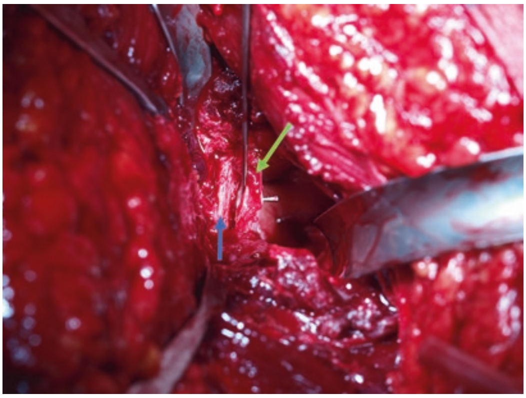

Fig. 5.7 Labrum detached from the acetabular rim by sharp dissection. Evaluation of the labrum with a small probe. *Green arrow*: detached labrum. *Blue arrow*: acetabular rim

Fig. 5.8 Sutures are passed through the labral substance. The definitive suture tightening will be performed only after hip reduction to obtain a more anatomic alignment of the labrum and a perfect knots tension

Isolated cam and pincer impingement are rare, and the majority of patients have a combination of the two mechanisms and, consequently, a mix of cartilage and labrum lesions. A low or negative femoral version will lead to anterior impingement, while coxa valga has a tendency for posteroinferior impingement [14]. Extra-articular impingement can happen between greater and lesser trochanter with the periacetabular bone; sometimes it becomes evident only after removal of the intraarticular impingement [15].

A blunt probe can be used to evaluate the labrum for detachment or tears. If labral tears are irreparable, then part of the labrum may be debrided. Results with labral reconstruction using autologous fascial tissue are encouraging [16].

In the area of maximum overcoverage, the labrum is detached from the acetabular rim by sharp dissection (Fig. 5.7). Then, the acetabular rim is resected with a curved osteotomy (Video 5.1) or a 5-mm high-speed burr. The amount of resection is roughly evaluated preoperatively on plain X-ray films and CT scan based on the cross-over sign and on the lateral center-edge angle, although these parameters depend very much on the radiological projection of the pelvis. The area of delaminated cartilage can be considered a good landmark for the magnitude of the rim resection and, as a general rule, every 1 mm of lateral resection corresponds to a reduction of 2° of acetabular coverage [7]. Intraoperatively, the rim excision is performed until no further impingement is present during repeated testing. Excessive resection can create hip instability and acetabular undercoverage similar to acetabular dysplasia. Peters and Erickson [17] suggested to perform excision of the delaminated cartilage with the underlying bone and then reattach the labrum on the newly created anterior aspect of the acetabular rim. However, it can create a higher risk of subsequent hip instability.

If full-thickness chondral lesions are identified, microfractures can be performed.

Following rim resection, the labrum is debrided of fraying and unhealthy tissue leaving as much viable tissue as possible. Reattachment is performed on bleeding bone surfaces using absorbable suture anchors [18, 19]. In most cases, 3–4 suture anchors are used [20]. To reattach or repair a torn labrum, the labrum, it has to consist of healthy tissue and sufficient dimensions. Philippon et al. [18] recommend a cut-off of at 7 mm of width of the labrum to repair and reattach it without augmentation. The anchors have to be placed 2–3 mm away from the cartilage surface. The anchors have to be directed away from the cartilage to avoid its penetration. The sutures are passed through the labrum in a piercing fashion (Fig. 5.8). Sutures can also be passed around the labrum in a loop fashion to avoid further tissue damages [18], a technique which has limited primary seal effect. Definitive tightening of the sutures is best performed after the hip is reduced; it provides a more homogeneous expansion of the labrum and tension on the knots [7]. The knots must be placed on the capsular side of the labrum to avoid contact with the articular surfaces [21, 22].

After an early phase of debridement of the labrum, labral reattachment became the method of choice, leading to better midterm results [6, 17, 18, 21, 23].

5.4 Femur

For an optimal exposure of the proximal femur, the leg remains in the sterile bag, the knee is lowered and the hip is adducted and externally rotated. Two blont Hohmann retractors are placed around the femoral neck (Fig. 5.9). Before any other maneuver the posterosuperior retinaculum with the vessels has to be identified and protected throughout the procedure [9]. If not done preoperatively, it is easy to check femoral version on the dislocated hip. An excessive high anteversion or the opposite, a retroversion, can produce impingement and should eventually be treated with caudal extension of the approach for a subtrochanteric osteotomy.

Usually, the femoral bump is localized at the anterosuperior head-neck junction. This area was described as an anterolateral bone bar from the anterior border of the greater trochanter to the femoral head and is probably the last part of the femoral neck to ossify.

The impingement area is usually characterized by an inflammatory appearance. The cartilage can have pink appearance and sometimes cysts near the nonspherical area can be identified [7, 24]. Transparent plastic templates are helpful to better identify amount and extension of the nonspherical area and to control the correction (Fig. 5.10).

Next step is the removal of the abnormal bone to restore a correct head–neck offset. This osteochondroplasty can be performed with a curved osteotome or with an high-speed burr [17] and had to be carried out carefully step by step with constant visual control of the retinacular integrity. Regular reevaluation of the contouring with the templates is mandatory as well as testing of impingement free motion (Fig. 5.11).

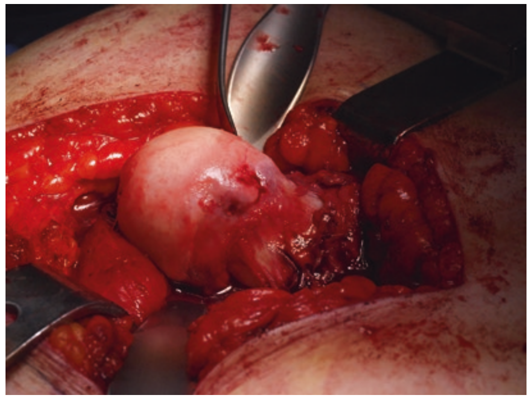

Fig. 5.9 Position of retractors for exposure of the femoral head and neck. The femoral head is further elevated with two blunt Hohmann retractors, placed around the neck

Fig. 5.10 Identification and evaluation of the femoral bump with sized transparent plastic template

The retinacular area with the vessels is about 2 cm large and can be visually identified. Regardless to the size of the bump, the retinaculum with the entrance area of the vessels in the femoral head has to be carefully preserved. If an impingement producing bump extends posteriorly over the retinaculum, resection has to not only respect the perforation area of the retinacular vessels [7] but also consider that the intraosseous course is rather superficially [25] (Fig. 5.12).

Overresection of the neck increases the risk of neck fracture and compromises the seal effect of

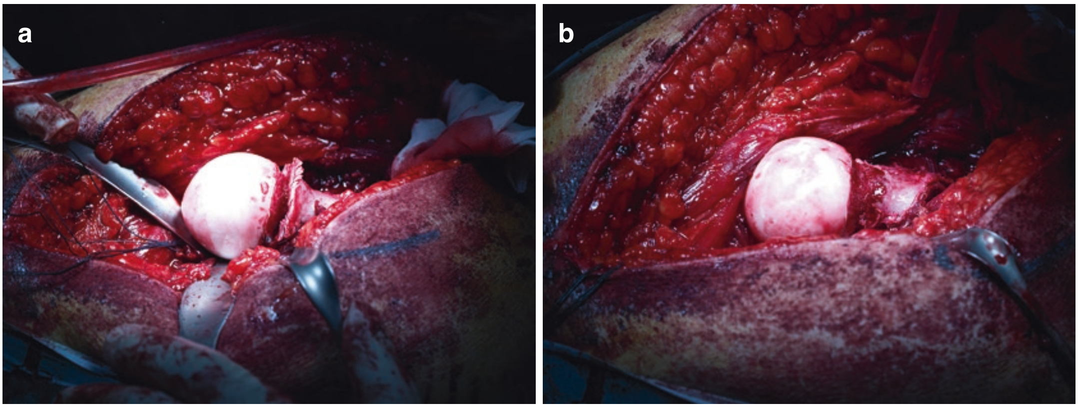

Fig. 5.11 (**a**) Osteochondroplasty of head–neck femoral junction. (**b**) Head–neck junction after the osteochondroplasty

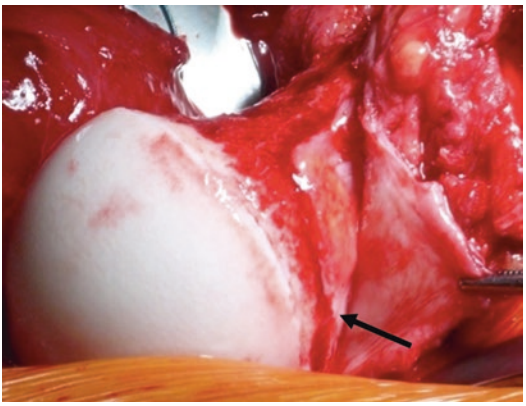

Fig. 5.12 Limited bone resection proximal to the retinacular flap. *Black arrow*: Posterosuperior periosteal flap

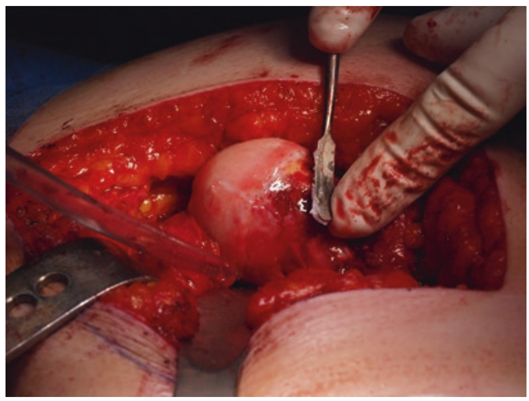

Fig. 5.13 Application of bone wax on the debrided bone surface

the labrum. Several authors reported that 30% of the diameter of the neck is the maximum resection without an increased risk of fracture [26–28].

Before reduction of the hip, the stump of the ligamentum teres can be debrided and bone wax can be applied on the debrided bone surfaces to reduce the bleeding (Fig. 5.13).

Nötzli et al. [29] reported that perfusion of the femoral head is reduced during dislocation by 10%. Intraoperatively, the "bleeding sign" can confirm the adequate vascularization of the femoral head. This test consists in a 2.0-mm drill hole carried out on the non-weight-bearing area of the femoral head and is considered positive for immediate appearance of active bleeding after drilling [1, 30]. This test has been validated as a reliable indicator of good femoral head prognosis after surgical dislocation [30]. Some authors reported the use of electronic devices to monitor the pulse wave generated by the blood flow into the spongious bone [29, 31]. However, these evaluations are time consuming and do not substantially change our ability to predict the femoral head vitality [30].

5.5 Reduction

Relocation of the femoral head is easily achieved with traction and controlled internal rotation with attention not to avulse labral sutures and not to invert the labrum. Relocation is much easier with the knee in flexion than in extension.

Following hip reduction and tightening of the sutures of the labrum, but before capsular closure, final assessment of the range of motion is performed to identify any residual impingement (Video 5.2).

Only the vertical incision of the capsule is repaired with loose running absorbable suture. Tensioning or even duplicating the capsule could create stretching on the retinacular vessels and decrease the perfusion of femoral head [29, 30, 32, 33].

The trochanteric fragment is then reduced. If a Z-osteotomy was performed, the anatomical reduction is easily achieved and the fragment can be fixed with two or three 3.5-mm screws from the lateral aspect of the greater trochanter towards the medial calcar [7]. If a straight osteotomy was performed, the greater trochanter fragment can be reduced in an anatomic position or advanced distally to respect relative lengthening of the femoral neck and improve function of abductors muscles; overcorrection however should be avoided. The straight osteotomy is also fixed with two or three 3.5-mm screws [19, 32] (Fig. 5.14). Fascia lata, subcutaneous tissue and skin are carefully sutured in a layered fashion.

Summary of Surgical Tips and Ticks

- Gibson's approach with a straight lateral incision provides better aesthetical results, avoiding saddlebag deformity.
- The trochanteric osteotomy should exit proximally just anterior to the most posterior insertion of the gluteus medius muscle to make sure that all external rotators remain on the stable part.
- Capsular exposure should begin strictly proximal to the piriformis tendon to protect the deep branch of the MFCA and all anastomoses.
- Avoid over-resection of the acetabular rim because it may lead to hip instability.
- Always try to repair and reattach the labrum to re-create the seal effect.
- Sutures for the labral reattachment must be tightened only after relocation of the head for best labral alignment and suture tightness.
- Avoid injury to the retinaculum vessels when performing the femoral osteochondroplasty.
- Excessive bone resection at the head-neck junction can weaken the femoral neck and increase the risk of fracture.
- Avoid tight suturing of the capsule.
- Avoid excessive distal advancement of the trochanteric fragment.

5.6 Conclusions

Treatment of femoroacetabular impingement by open surgical dislocation is characterized by several advantages. First of all, the procedure is safe regarding the risk of avascular necrosis and the morbidity is low. Second, surgical dislocation provides a complete direct visualization of the entire acetabulum and proximal femur and, consequently, major pathologic deformities can be identified and treated. Third, with a single surgical approach, the surgeon can perform several surgical procedures on the acetabulum, the femur and the soft tissues.

The efficacy of treatment of femoroacetabular impingement has been demonstrated for both arthroscopic and open surgery; both have specific indications. Evaluation of all deformities, possibly leading to impingement, is fundamental.

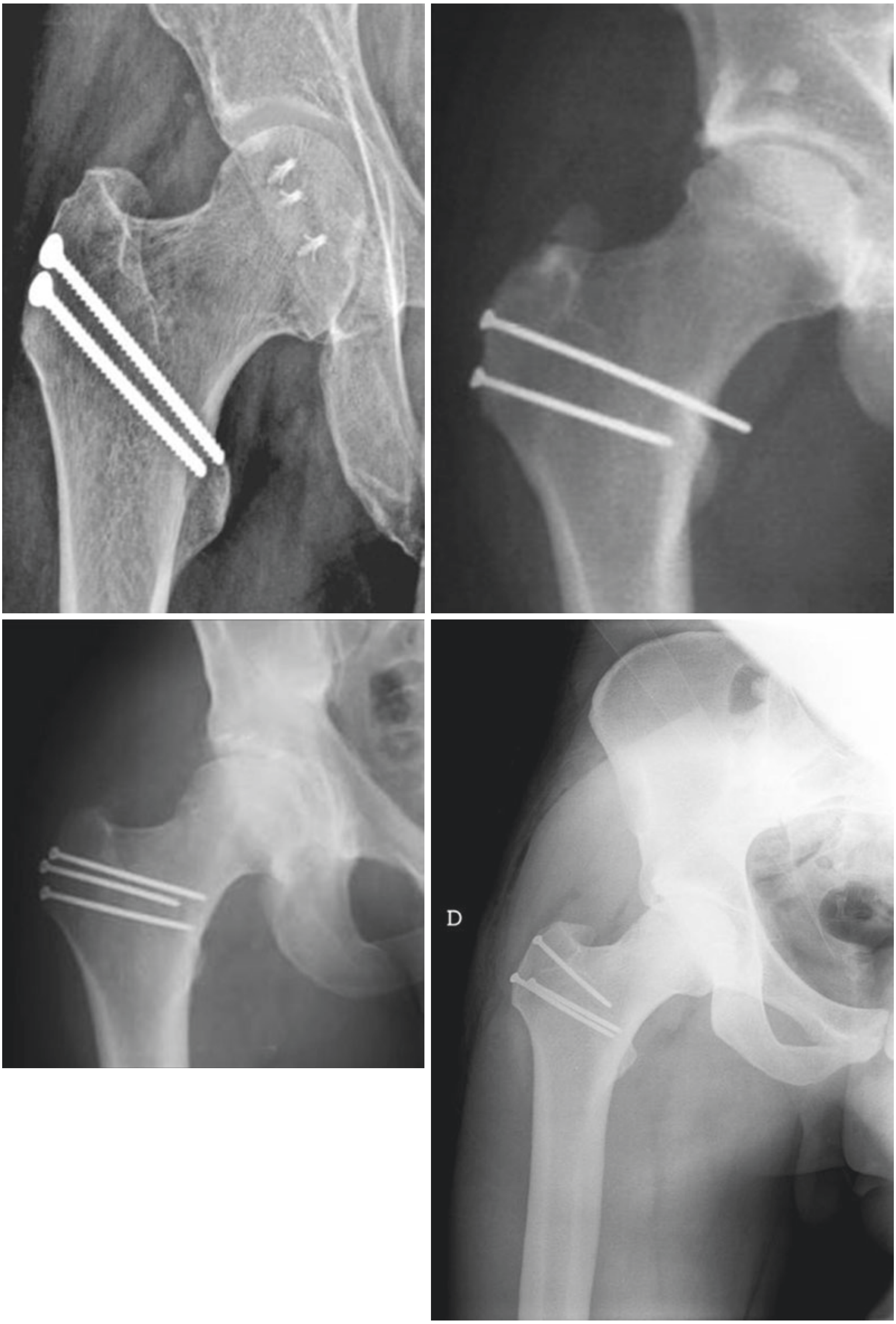

Fig. 5.14 Postoperative X-rays. Fixation of the trochanter with 3.5-mm screws

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