Femoral Osteochondroplasty

3

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3.1 Femoroacetabular Cam Impingement

Cam femoroacetabular impingement (FAI) is the femoral-induced component of FAI. It results from either local deformity of the head–neck transition or global orientation pathologies [1] (Table 3.1). The etiology and pathogenesis of Cam FAI are under current evaluation and not yet completely understood. However, there are strong indicators that the typical aspherical deformity of the head–neck transition is frequently a result from a growth plate disturbance during adolescence [2]. The causes are likely high-level sports activities and extremes of range of motion during the maturation age leading to physeal injury and abnormal growth patterns [3–5].

Asphericity of the head–neck junction is the most common pathologic morphology of Cam FAI. Typically, the deformity is located anterolateral but does not rarely extend laterally and posterolaterally ("pistol grip deformity"). In Cam FAI, the primary damage is at the hyaline cartilage of the anterolateral rim, whereas in Pincer FAI the acetabular labrum is injured first [6]. Deep flexion in combination with internal rotation leads to outside-in shearing forces between the femoral head and rim cartilage resulting in cartilage delamination and separation from the underlying bone. In contrast to Pincer, the elastic labrum is initially spared until chondrolabral separation occurs, then instability and degeneration start. With continuous injury, the head migrates into the articular defect with subsequent chondral damage of the head and radiological appearance of joint line narrowing [1]. Not only the size of deformity but also suddenly accelerated movements and extreme range of movements (contact sports, dancers) are important determining factors for progressive damage [7].

Table 3.1 Etiology of Cam FAI

Local deformities	– Asphericity of the femoral head–neck transition and/or thickening of the femoral neck/loss of head–neck–waist – Coxa magna (s/p Perthes disease) – Local deformity from nonanatomically healed fractures
Global malorientation	– Retrotorsion – Retrotilt (s/p slipped capital epiphysis [24, 25], femoral neck fracture [26])

3.2 Patient Selection

The diagnosis of FAI is made from the typical symptoms in combination with physical and radiological examination. Pain reproduction with physical provocation and the correlation of clinical findings with bony deformities and collateral damage visible on radiographs and magnetic

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resonance (MR) imaging are of high importance. Surgical corrections based on radiological findings only as a prophylactic procedure in asymptomatic patients in order to avoid further deterioration of the joint are not yet justified. While the direct causative relation between FAI and chondrolabral damage has been proven by multiple studies, data supporting prophylactic surgery are still missing.

Patient selection is a complex and important process. Patient symptoms and their duration, clinical examination findings, including joint functional status, radiographic findings, patient expectations, and surgeon's experience must all be taken into consideration during the decision process. Poor patient selection is associated with patient unsatisfaction, persistent complaints, higher failure, and total hip conversion rates.

The **most important questions during the decision process** that need to be addressed are as follows:

- To what extent are the patient's complaints caused by the hip?
- Is hip preservation surgery still justified or is total hip arthroplasty the better solution?
- Which pain level justifies operative joint preserving treatment?
- Can the hip pathology be treated adequately by arthroscopy or should an open procedure be considered?

The question if and **how many of the patients' complaints are caused by the hip** is sometimes difficult to be answered. Hip pain may be mimicked by pathologies originating from the lumbar spine, sacroiliac joints, urogenital, gastrointestinal system, and inguinal region. In addition, even if the hip is the primary pathology, pain may originate from periarticular pathologies that are the sequelae of a reduced hip function. In unclear cases, the easiest test to find out how much pain is directly coming from the joint is an intraarticular injection with local anesthetic with the optional combination of cortisone.

Frequently, patients with FAI present with advanced collateral damage where joint preserving surgery is critical. Particularly in those patients, the **decision between joint preservation surgery and nonoperative therapy with later joint replacement** is often more difficult because of the young age and relatively high expectations. This decision is always individual.

Along with the aforementioned discussion about prophylactic surgery goes the question **which pain level justifies the indication for joint preserving surgery**. It needs to be considered that the FAI deformity itself does not cause pain. The patient's complaints are the result from the collateral damage at the chondrolabral complex and periarticular changes from the reduced joint function. On the other hand, it needs to be stated that, also in young patients, the damage can be already advanced even if the pain level is low. Thus, surgical intervention should be considered early even in patients where the pain is minimal and only with sports activities. As an alternative, impingement sports should be terminated, and the patient scanned with MR imaging regularly. If the follow-up MR images show progression of joint deterioration, surgery is recommended.

3.3 Operative Treatment

3.3.1 Principles

Cam FAI can be treated by **different operative techniques**. Historically, FAI was first observed and treated by Ganz and coworkers via open surgical dislocation [1]. Within the past decade, less invasive mini-open anterior and anterolateral approaches with or without arthroscopic assistance and fully arthroscopic techniques were developed. Meanwhile, most FAI cases are being treated by arthroscopy. However, the **decision which technique should be used to treat FAI** adequately depends on various factors.

- FAI type and severity of deformity: The more severe the Cam and Pincer deformity, the more difficult is a minimally invasive technique for adequate treatment of both the bony deformity and collateral damage. In other words, global deformities and pathologic orientation may be better treated by surgical

dislocation that offers full exposure of both the proximal femur and acetabulum and offers the combination with corrective osteotomy.
- Condition of the acetabular labrum: If the labrum is degenerated or mostly ossified, detachment and/or repair of the labrum is usually not indicated. In those cases, treatment of FAI is technically less demanding and feasible via minimally invasive techniques.
- Grade of arthritis: The more advanced the joint degeneration, the more questionable is the balance between surgical risk, postoperative rehabilitation and benefit. Here, mini-open solutions and arthroscopy may be preferable with smaller risks and less demanding postoperative rehabilitation.
- Experience of the surgeon: Besides FAI type and deformity, the training and experience of the surgeon are probably the most important factor. Experienced hip arthroscopists can manage even more global combined FAI cases, while hip arthroscopy beginners may even not be able to treat mild FAI types. It needs to be considered that not only the deformity needs to be corrected but also the collateral damage at cartilage and labrum treated.

The most important goal is an adequate and successful treatment of FAI and its collateral damage. Thus, the decision which technique is used should be based on the aforementioned aspects and not on the current trend to prefer minimally invasive techniques such as arthroscopy. In addition, advantages and disadvantages of the different operative techniques should be considered.

From the authors' experience, most local and moderate global Cam deformities can be handled arthroscopically. For treatment of the more lateral and posterolateral cam deformities (pistol grip), more experience is needed. In those cases, less experienced arthroscopic surgeons should consider exposure and treatment via a surgical dislocation. Moderate global Cam pathology such as the status post slipped capital femoral epiphysis (SCFE) up to a posterior slip of about 30°, antetorsion of the femoral neck of not less than about 0°, and moderate coxa magna after a Perthes disease can be treated via arthroscopy. More significant global pathologies may be better treated by surgical dislocations in combination with subcapital or intertrochanteric osteotomies, head reduction osteotomy, neck lengthening, and/or distalization of the greater trochanter. The cutoff and decision whether to prefer a less aggressive treatment or going for the osteotomy need to be further studied [8].

3.3.2 Arthroscopic Technique of Cam Resection

3.3.2.1 Cam Resection: Principles and General Considerations

The **goal of Cam resection** is to re-create the physiologic convex–concave transition between the femoral head and neck without losing the normal roundness of the femoral head, not to distort the labral seal, with a smooth cartilage–bone transition proximally, creating adequate offset to the femoral neck without causing stress risers at the femoral neck.

There are **different technical challenges** that need to be addressed during arthroscopy for the treatment of Cam FAI:

- Limited overview and visibility: In order to assess the extent of the Cam deformity and control the resection, an adequate overview is crucial. However, particularly at the maximum of the Cam deformity at about 1 o'clock (right hip), the iliofemoral ligament is thick and tight. In order to relax the ligament and increase the working space, the hip needs to be flexed, and, in addition, the ligament could be released or partially removed according to its thickness and rigidity.
- Two-dimensional arthroscopy vs. three-dimensional deformity and operative treatment: Particularly for beginners, the three-dimensional Cam resection is difficult for both viewing and instrumentation. Intensive dry and wet lab training as well as in vivo practice are mandatory.
- Limited orientation: Orientation around a ball-in-socket joint is demanding. Clear land-

marks for the Cam resection are rare. In addition, orientation depends significantly on the joint position, particularly on flexion and rotation, and coverage of the head by the acetabulum. Thus, soft tissue landmarks such as the medial and posterolateral folds should be preserved. The joint position needs to be monitored during orientation and resection process. In case of limited orientation, fluoroscopy should be used during the operation.

- Influence by acetabular coverage and labral width: The grade of acetabular coverage has a significant impact on the distance of the proximal border of Cam resection to the acetabular labrum. In dysplastic sockets, where the coverage is reduced, the proximal border of Cam resection needs to be further away from the acetabular labrum.
- Bleeding from exposed bony surface, synovial tissue, and capsule: Visibility can be significantly reduced by persistent bleeding from the exposed bony surface, synovectomy area, and partially resected capsular surface. Probably the most important tip avoiding bleeding is to keep the systolic blood pressure low. Ideally, the systolic blood pressure should be between 80 and 90 mmHg.

3.3.2.2 Strategies for Access and Operative FAI Treatment

Different strategies to access the hip and manage FAI have been developed:

- **Central 1st:** This is the technique that has been developed first and is being used worldwide most often. Under traction and fluoroscopy control, the CC is accessed. After a variable extent of capsular work and diagnostic round, rim trimming and chondrolabral pathology are treated first, before the PC is accessed and, after additional variable capsular work, the bony Cam deformity is resected.
- **Peripheral 1st:** After "detection" of the PC, Dorfmann and Boyer and the senior author developed the peripheral first technique [9–11]. Here, the PC is accessed under fluoroscopic control without traction. After a variable degree of capsular work, the Cam deformity and potential labral ossifications are resected or trimming of an overhanging acetabular rim in coxa profunda is performed. Under traction, portals to the CC are placed under arthroscopic control. After additional capsular work of variable extent, rim trimming is performed and potential chondrolabral pathology is treated.
- **Extracapsular 1st:** This is the latest technique that has been developed during the past years [12, 13]. With or without fluoroscopy, and without traction, the instruments are brought to the space anterior to the joint capsule. The anterolateral capsule is incised longitudinally and, if exposure is not sufficient, another incision parallel to the acetabular labrum leading to a T-shape capsulotomy could be performed ("endoscopic Hueter approach"). Depending on the surgeon's preference, the PC or CC is accessed and treated first.

Each strategy has **advantages and disadvantages:**

• Central 1st:	⊕	Direct detection of collateral damage at anterolateral rim
	⊖	Higher risk of iatrogenic damage to cartilage and labrum during first access
	⊖	Reduced visibility in the PC caused by capsular flaps and loss of capsular tension
	⊖	Difficult/impossible in coxa profunda/ossified labrum
• Peripheral 1st:	⊕	Safe access with less risk to cartilage and labrum
	⊕	Good visibility in the PC
	⊕	No need of capsular repair (if longer capsular incisions are avoided)
	⊖	Detection of collateral damage only after access to CC
• Extracapsular 1st:	⊕	Safe access with less risk to cartilage and labrum
	⊕	Good visibility in the PC (if capsular flaps are avoided)
	⊖	Detection of collateral damage only after central access
	⊖	Capsular repair needed to avoid postoperative instability
	⊖	Fluid extravasation into soft tissues

The Peripheral first technique is the authors' preferred technique and described later.

It needs to be considered that **most Cam pathologies cannot be adequately resected without traction**. Only the rare "easy" more anterior than lateral Cams can be handled without traction from the PC. If the AP radiograph indicates lateral and posterolateral extension of the Cam, the head needs to be distracted from the posterolateral labrum and acetabular rim to expose the otherwise covered deformity. Thus, the posterior and posterolateral extension of the Cam is better addressed through the CC. In addition, the CC needs to be checked for collateral chondrolabral damage. Thus, a traction device has to be used in all cases.

3.3.2.3 Portals

The authors prefer a three-portal technique for arthroscopy of the PC and a 2–4 portal technique for arthroscopy of the CC (Fig. 3.1a, b). For resection of the anterolateral Cam in the PC, the scope is introduced via the proximal anterolateral portal, and instrumentation is done via the anterior and classic anterolateral portals. For exposure and instrumentation of the posterior and posterolateral pistol grip, the scope is inserted via the anterior portal to the CC, and the burr is working via the anterolateral or lateral portal.

Proximal anterolateral portal to PC (PALP^{PC}): The skin is incised at the soft spot between anterior border of gluteus medius and the lateral border of the tensor fascia lata on the junction between upper one-third and lower two-thirds of a line connecting the anterior superior iliac spine (ASIS) and tip of the greater trochanter. The needle is directed under fluoroscopic guidance perpendicular to the neck axis close to the head–neck area and penetrating the capsule at 1 o'clock position (right hip). This penetration point is of most importance as it will allow the lens to wind around the anterolateral head–neck junction falling into the lateral aspect of the joint allowing visualization of the anterior, lateral, and partly also posterolateral Cam deformity. This is the viewing portal where the lens is kept during the whole Cam resection procedure within the PC.

Anterior portal to PC (AP^{PC}): The skin incision is about 3 cm lateral to the line connecting the ASIS and patella, about 2–3 fingers breadth and 30° anterodistal to the PALP^{PC}. The needle is perforating the capsule proximal to zona orbicularis between 2 and 3 o'clock (right hip) in order to have better access to the anterolateral part of the head–neck junction. This is the main working portal for resection of the anterolateral Cam deformity.

Anterolateral portal to PC (ALP^{PC}): The skin incision is the same as the anterolateral portal to the CC. The direction of the portal is more horizontal, so that the capsular perforation is further distal at the most lateral part of the femoral head curvature. This portal is used for lateral and posterolateral Cam resection with and without traction.

Anterolateral portal to CC (ALP^{CC}): Using the same skin incision of *ALP^{PC}*, the needle is redi-

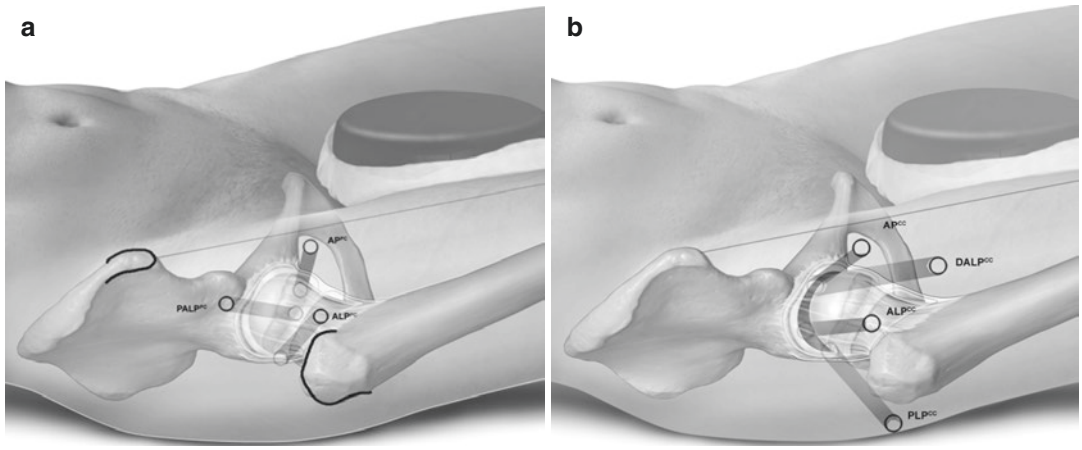

Fig. 3.1 (**a**, **b**) Portals to the PC (**a**) and CC (**b**). Courtesy of Michael Dienst, MD

rected into the central compartment at about 12 o'clock superiorly (right hip). This is usually our first CC-Portal, done under direct vision from PC.

Anterior portal to CC (AP^{CC}): Using the same skin incision of AP^{PC}, the needle is redirected into the central compartment at about 3 o'clock anteriorly (right hip). Placement of the AP^{CC} is visualized from the ALP^{CC}.

3.3.2.4 Steps of Cam Resection

Exposure of the Cam Deformity (PC)

In cases of symptomatic FAI, a variable degree of synovitis and capsular thickening is almost always found. The first steps include partial synovectomy as well as a selective capsular release. This will allow an adequate arthroscopic overview and maneuverability of scope and instruments. It has also a therapeutic postoperative effect of increased range of hip motion.

With the scope in the $PALP^{PC}$ and the shaver introduced via the AP^{PC}, the hip is flexed to about 30°–40° in order to relax the anterior structures giving more room for working anterior to the head–neck junction and hide the femoral head cartilage under the acetabulum. Synovectomy and capsular thinning start by opening the perilabral sulcus anteriorly. The scope is located anterior to the femoral head–neck junction with the lens rotated proximally. With the shaver positioned proximal to the arthroscope, thinning of the anterolateral and lateral parts of the iliofemoral ligament is started lateral to the psoas tendon in order to avoid connecting the hip joint with the psoas tendon sheath.

The lens is rotated distally to view the anterolateral zona orbicularis, and the shaver is moved distal to the scope into the viewing field. Release of the circular fibers of zona orbicularis again starts anteriorly moving laterally (Fig. 3.2). Bringing the scope in a more vertical position, the lateral and posterolateral parts of the zona can be viewed and addressed with shaver from anterior. Moving back and forth with the shaver either proximally or distally, release of the circular fibers of the zona orbicularis is advanced until a complete overview of the peripheral part of the Cam deformity is achieved (Fig. 3.3).

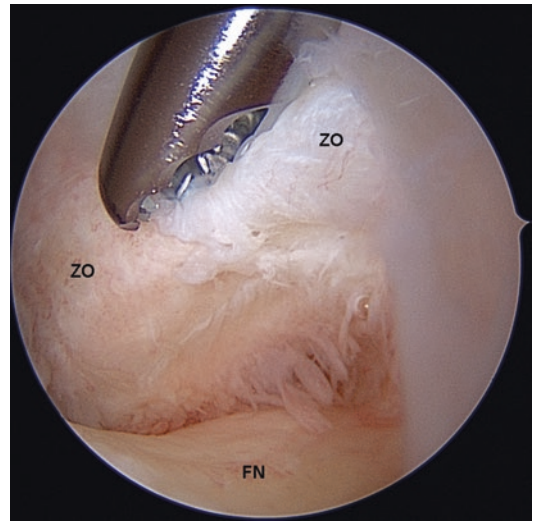

Fig. 3.2 Release/internal thinning of the Zona orbicularis (ZO). View from the $PALP^{PC}$, Shaver via AP^{PC}. *FN* femoral neck. Courtesy of Michael Dienst, MD

A radiofrequency (RF) probe is introduced for hemostasis and shrinkage of the frayed tissue of the capsule. The anterolateral soft tissue and periosteum overlying the femoral head–neck junction are removed and the bony surface of the femoral neck is exposed.

Identification of Landmarks and Delineation of the Cam (PC)

Before the Cam resection is initiated, the joint position needs to be monitored, the radiographs viewed, the landmarks identified and possibly also the borders of Cam resection marked.

Monitoring the joint position: The position of the joint has a significant impact on the relation between the head–neck junction and the acetabular labrum/rim. From our experience, it is beneficial to start with anterior Cam resection in a hip flexion of about 30°. For the lateral Cam resection, the hip is progressively brought into extension.

Correlation with radiographs: The radiographs need to be observed during the whole surgery. The surgeon needs to correlate the arthroscopic image with the preoperative radiographs. Here, especially the relation between the proximal extension of the Cam and the anterior and lateral rim needs to be analyzed.

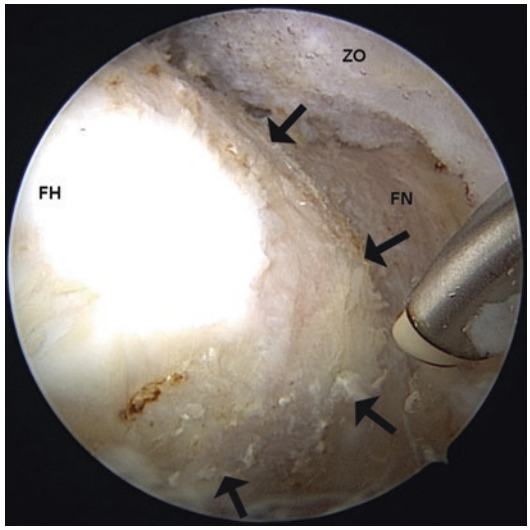

Fig. 3.3 Assessment of the extent of the Cam deformity (arrows). View from the PALP[PC]. *FN* femoral neck, *FH* femoral head, *ZO* Zona orbicularis. Courtesy of Michael Dienst, MD

Identification of landmarks: The following landmarks need to be identified before and during the resection process: the medial and posterolateral folds, the acetabular labrum and the femoral neck (Fig. 3.3).

- Medial synovial fold: Its attachment at the anteromedial head–neck junction at about 4:30–5:30 o'clock (right hip) represents a stable landmark. The Cam resection is started just proximal to its attachment.
- Posterolateral synovial fold: This lateral border of this fold is located most often between 11:20 and 00:40 o'clock (right hip). The fold covers the posterolateral retinacular vessels that must be protected to avoid avascular necrosis of the head. In this area, osteoplasty is limited to the femoral head and must not be extended to the neck distally.
- Acetabular labrum: The proximal border of the Cam resection forms a straight line connecting the aforementioned point proximal to attachment of medial synovial fold with a point close or underneath the acetabular labrum laterally at the 12 o'clock position. The distance between this line and the labrum is determined by two variables; the degree of acetabular coverage and degree of hip flexion and rotation. In cases with focal or global retroversion, the line and border of resection need to be closer to the labrum anteriorly. Lateral and posterolateral, the resection needs to be advanced underneath the labrum so that the head has to be distracted for exposure. As an alternative, the rim may be reduced first before the Cam is addressed.
- Femoral neck level: The level of the neck needs to be assessed on both the anteroposterior and lateral radiographs and correlated with the intraoperative view. In many cases, the neck is thickened so that an adequate offset correction will require a thinning out of the femoral neck. Frequently, the anteromedial neck offset is not affected, so that this contour can be used as a template for the offset correction of the anterior and lateral neck. In most cases, the resection needs to be advanced distally, almost down to the level of the intertrochanteric line.
- Prominent Cam deformity: Sometimes the Cam is very prominent and presents with a step off at the distal end of the bump toward the neck. Correlation with the preoperative radiographs gives very valuable information for arthroscopic orientation and resection.
- Herniation cysts: Herniation pits are usually not seen before the resection process is started. However, location and size of the cysts are very helpful when the cysts are exposed during the Cam resection. Correlating the cysts with preoperative radiographs and MR images gives important information about depth and location of resection. It needs to be considered that the floor of big cysts can exceed the depth of the Cam resection level and must not be completely incorporated in the Cam resection.
- Epiphyseal growth plate in adolescents: Similar to the herniation pits, the epiphysis is not seen before the Cam resection is started. During the resection, the growth plate needs to be included in the Cam resection. Location of growth plate and correlation with the radiographs provide important information about proximal level of resection.

Delineation of the Cam resection: It may be beneficial to mark the proximal borders of resection with an RF device or with the burr before the resection process is started and anatomy may be distorted. This step is helpful especially in the beginning of the learning curve not to lose orientation later during osteoplasty.

Anterolateral Cam Resection (PC)

For Cam resection, a 5.5-mm-long acromionizer or round burr is used. Cam resection is initiated proximal to the origin of the medial synovial fold. The scope is introduced via the PALP^{PC}, lying anterior to the femoral neck and looking proximally in order to get an overview of the anteromedial head–neck junction including the anteromedial labrum and origin of the medial synovial fold. With the hip flexed to about 30° and in neutral rotation, the burr is introduced via the AP^{PC}. The anteromedial extension of the Cam is resected, starting just proximal to the medial synovial fold (Fig. 3.4a).

The scope is moved toward the head and rotated distally so that the anteromedial neck is viewed, while the burr is shifted distally toward the neck. The proximal resection is advanced toward the anteromedial neck underneath the medial synovial fold where the contour and offset are mostly normal. Starting from here, the physiological neck waist is developed toward the anterior and lateral neck. From our experience, it is beneficial to move the burr in a circular fashion around the axis of the femoral neck. This minimizes the risk of overresection (Fig. 3.4b).

The arthroscope is again moved back to the neck, retracted as far as possible to the capsule and rotated proximally for viewing of the anterolateral head. With the burr still in the AP^{PC}, the proximal border of the anteromedial Cam resection is developed laterally toward the labrum at 12 o'clock.

The viewing angle of the scope needs to be changed multiple times between the more distal position and upward viewing and the more proximal position and downward viewing in order to change the perspective and achieve an optimal convex–concave shape and adequate depth of resection.

Lateral Cam Resection (PC)

For resection of the lateral extension of the Cam, the hip is gradually brought into full extension and variable degrees of internal rotation. With the burr still introduced via the AP^{PC}, internal rota-

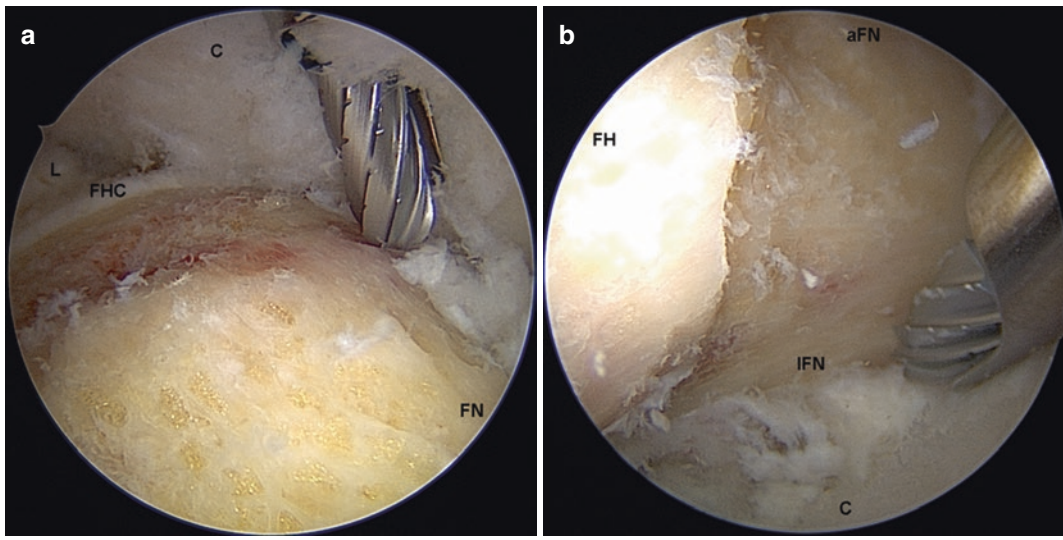

Fig. 3.4 (**a**, **b**) Resection of the anterior (**a**) and anterolateral (**b**) extent of the Cam deformity. View from the PALP^{PC}, burr via AP^{PC}. *C* capsule, *FN* femoral neck, *aFN* anterior femoral neck, *lFN* lateral femoral neck, *L* acetabular labrum, *FH* femoral head, *FHC* femoral head cartilage. Courtesy of Michael Dienst, MD

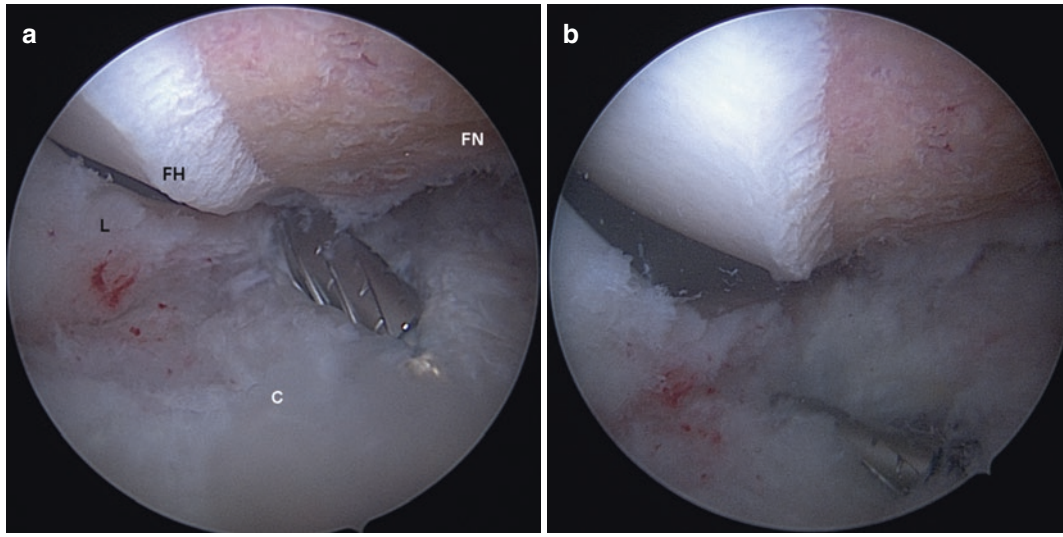

Fig. 3.5 (**a**, **b**) Lateral extent of the Cam deformity before (**a**) and after (**b**) resection. View from the PALP^{PC}, burr via ALP^{PC}. *C* capsule, *FN* femoral neck, *aFN* anterior femoral neck, *LFN* lateral femoral neck, *L* acetabular labrum, *FH* femoral head. Courtesy of Michael Dienst, MD

tion brings the more lateral part of the femoral head–neck junction into the working range of burr from the AP^{PC}.

Most often, for a complete resection of a lateral Cam deformity, the burr needs to be moved to the ALP^{PC}. At the capsular perforation site, the strong lateral iliofemoral ligament has to be incised parallel to the labrum over a length of about 10 mm to allow sufficient maneuverability of the instrument. If the incision is limited, a later repair is not necessary. With the arthroscope still in the PALP^{PC}, the burr is advanced to the anterolateral border of Cam resection posterolaterally (Fig. 3.5a, b). In most cases, the head needs to be distracted from the labrum in order to create a few millimeters space between the femoral head and the labrum, allowing extension of the resection posteriorly underneath the labrum. From this position, the proximal posterolateral resection is again connected with the neo-waist at the lateral femoral neck. The posterolateral resection with the burr introduced via ALP^{PC} must be restricted to the femoral head and not be extended to the femoral neck in order to avoid injury of the end vessels of the medial circumflex femoral artery (MCFA). If the fluid pressure is decreased, arterial pulsation can sometimes be visualized in the periosteum medial to the fold.

Posterior/Posterolateral Cam Resection (CC)

When pistol grip deformity is prominent, Cam resection needs to be advanced further posteriorly. Frequently, this cannot be handled via the PC and must be addressed while the arthroscope is introduced from the CC.

With distraction of the head from the socket and arthroscopic control from the PC, the AP^{CC} and ALP^{CC} are placed to the CC. The PALP^{PC} is maintained with a nitinol wire or a small outflow cannula. The arthroscope is moved to the AP^{CC}, and the burr is moved to the ALP^{PC} and not to the ALP^{CC}. The direction of the ALP^{PC} toward the posterolateral Cam is better; in addition, the capsule has already been incised to allow better motion of the burr toward the posterolateral Cam. The posterolateral and posterior Cam can be easily addressed through applying various degrees of internal rotation (Fig. 3.6a, b).

Arthroscopic and Fluoroscopic Control of Adequate Cam Resection

Finally, optimum Cam resection needs to be confirmed (Fig. 3.7a–c). After addressing the CC, AP fluoroscopic images in various degrees of internal rotation are done to check the contour of lateral and posterolateral head–neck junction. Then, traction is released, and fluoroscopic images are obtained in different degrees of flexion and abduction to check the contour of the anterior/anterolateral head–neck area.

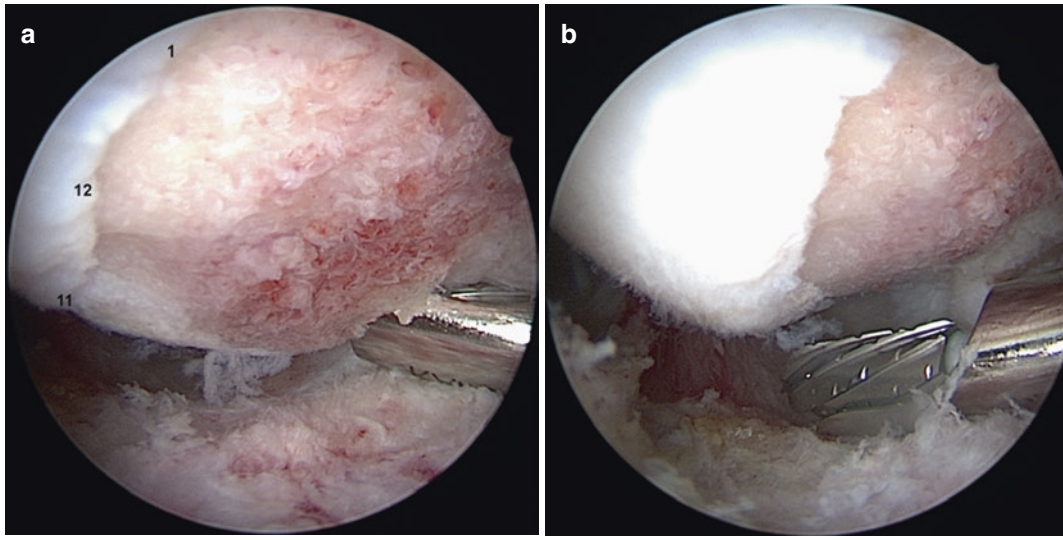

Fig. 3.6 (**a**, **b**) Resection of the lateral/posterolateral extent of the Cam deformity from the central compartment. View from the AP^{CC}, burr via ALP^{PC} before (**a**) and after (**b**) resection. Courtesy of Michael Dienst, MD

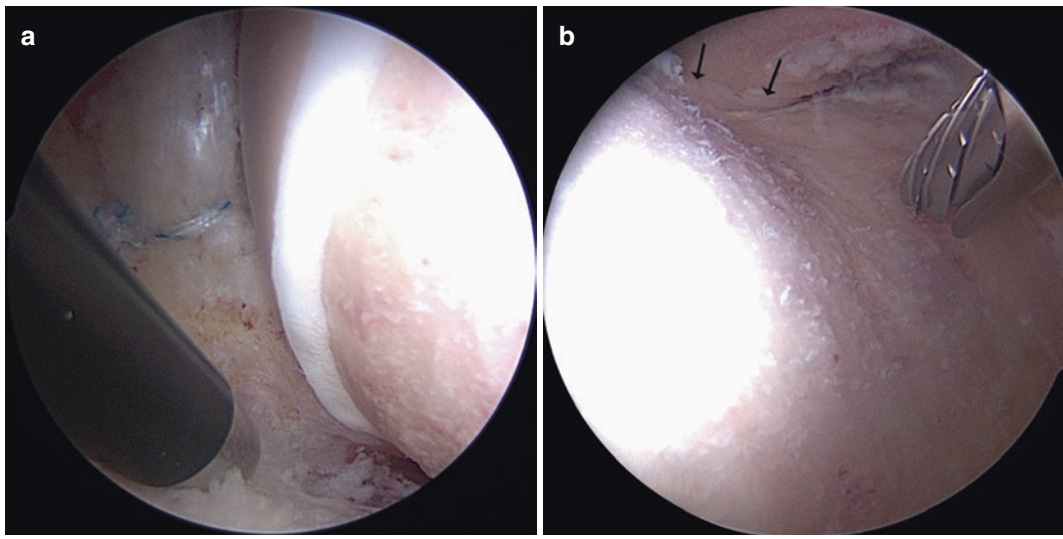

Fig. 3.7 (**a–c**) Final arthroscopic viewing of an adequate Cam resection. Lateral head area with the relation of the lateral to the repaired labrum (**a**), anterior head–neck junction (**b**) with a precise transition of a concave–convex shape with view medially to the medial synovial fold (arrows) and lateral head–neck junction (**c**) with preservation of the posterolateral synovial fold (arrows) containing the blood-supplying vessels to the femoral head. Courtesy of Michael Dienst, MD

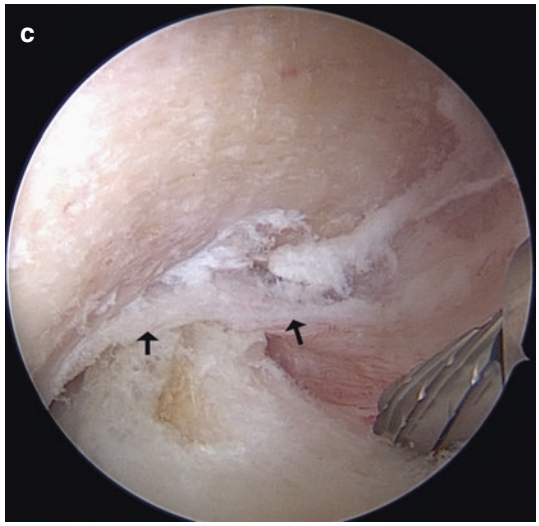

Fig. 3.7 (continued)

3.4 Postoperative Care

Wound care: Postoperative, a thick dressing is applied to absorb leakage of fluid from the portals. Sutures are removed after 14–16 days.

Medication: All patients receive nonsteroidal anti-inflammatory drugs for at least 10 days after the operation in order to reduce postoperative edema, joint effusion, and the risk of developing heterotopic ossification. Prophylaxis of thromboembolism with daily subcutaneous injection of a low-molecular-weight heparin until full weight bearing is achieved.

Weight bearing: In cases of pure Cam resection without labral repair or cartilage procedures, the patient is advised to proceed to full weight bearing over a period of about 10 days. Impacting activities are however prohibited for 6 weeks in order to avoid stress fracture of the femoral neck. In case of osteoporosis, the impression of weaker head–neck–bone during arthroscopy and particularly female patients over 40 years of age, partial weight bearing to half body weight is recommended for 4 weeks because of the higher risk of fatigue fracture. After labral repair, partial weight bearing of 20–30 kg is recommended for 3–4 weeks, and, after abrasion, microfracture of other advanced cartilage procedures for 6 weeks.

Range of movement and continuous passive motion (CPM): Range of movement is not restricted and allowed as tolerated. Painful passive flexion or rotation should be avoided. Continuous passive motion is initiated from the first postoperative day and continued for 4–6 weeks at least 3 times a day with 30 min each to avoid intra-articular adhesions, reduce swelling, and support cartilage regeneration and labral remodeling. Stationary bike exercises can be added in the third week.

Physiotherapy: Physiotherapy can start at the first postoperative day with gait training and isometric strengthening exercises. Proprioceptive and coordinative training can be started in partial weight bearing and progressed to full weight bearing, depending on pain, treatment of chondrolabral damage, and bone quality. Physiotherapy has to include active and, in the beginning, gentle passive mobilization of the hip. Later, usually not before week 8, rubber band and flexible board training can be started for innervation training of external rotators and abductors. At this stage, static and dynamic exercises for stability in the two-leg and later one-leg stance should be started. After regaining stability, strength and endurance must be trained. The athlete usually starts with controlled sports-specific training between weeks 9 and 14.

Return to sport: The return to sport at competition level depends on various factors such as the condition of the joint, the operative procedures, and, last but not least, the type of sport. From our experience, most high-level athletes need 4–5 months before they return to competition.

3.5 Pitfalls

Several studies indicated a small rate of complications for hip arthroscopy [14–16]. However, the risk significantly increases in case of less experienced hip surgeons.

- **Persistent Cam FAI (Cam underresection):** Underresection of the Cam and a persistent Cam FAI is probably the most common cause for revision hip arthroscopy. It leads to residual impingement with persistent symptoms and ongoing joint deterioration [17]. Cam underresection is not uncommon in the beginning of the learning curve. Limited arthroscopic overview, underestimation of the extents of the Cam deformity, and problems how to access the deformity are the main causes for failure. Frequently, the resection is limited to the anterolateral Cam but not sufficient at the lateral or posterolateral extension of the Cam.
- **Loss of labral seal/joint vacuum (Cam overresection):** Overresection of the Cam is less frequent. Usually, the resection is either too deep and/or too proximal. Both conditions lead to loss of contact of the acetabular labrum and acetabular cartilage with the cartilage of the femoral head resulting in loss of the labral seal and contact between the hyaline cartilage surfaces during flexion and rotation of the hip. Results from finite element studies suggest that higher and shifted forces during loading and motion lead to earlier secondary osteoarthritis. In addition, overresection results in a higher risk of acute or fatigue fracture [18, 19]. Revision is much more difficult in comparison to an "easy" arthroscopic reresection.
- **Hip instability (resection/big incisions of capsule):** Several authors have been promoting more aggressive work on the capsule in order to ease access to the head–neck junction including bigger T-shape iliofemoral ligament incisions and partial capsular resections. Recent case series suggested frank dislocations and subtle instability as a complication from those approaches. Meanwhile, there is accordance that the capsule must not be resected and that bigger incisions need to be repaired [20, 21].
- **Stress fracture of the femoral neck:** Stress fracture of the femoral neck after Cam resections have been reported. Möckel and Labs [22] reported 12 (0.1%) stress fractures of the femoral neck in a retrospective multicenter study of 13.154 patients over a 5-year interval. Potential risk factors are more extensive Cam resection, early impacting sports and an inferior bone quality in older and osteoporotic patients or patients under immune suppression. Thus, with such risk factors the transition to full weight bearing needs to be postponed to weeks 4–6. Typically, patients developing stress fractures present with increasing pain about 4–5 weeks postoperatively. At that time, radiographs are usually equivocal, and diagnosis is confirmed with MR imaging.
- **Avascular necrosis of the femoral head (AVN):** Review of the literature shows that this complication is very rare. In the multicenter study of Möckel and Labs [22], 7 of 13,154 patients showed AVN after arthroscopic Cam resection.
- **Intra-articular adhesions:** Adhesions occur between the exposed bony surface and opposing capsule. Willimon et al. reported a rate of 4.5% after hip arthroscopy and identified younger age, more bony resection, and missing circumduction therapy during the postoperative rehabilitation as risk factors for development of this complication [23]. There is accordance that continuous motion therapy and early rotational and abduction exercises are crucial to avoid the formation of adhesions.

3.6 Literature Overview

Table 3.2 shows an overview of a selected case series of arthroscopically managed FAI.

Table 3.2 Results of arthroscopic treatment of Cam FAI

Authors	N	M/F	Cam/Pincer/mixed	F/U mean (range) [months]	Outcome	Complications
Larson and Giveans [27]	100	54/42	17/28/55	9.9	• mHHS ↑ 22 points • SF 12 ↑ 18 points • VAS for pain from 7 to 2 • Pos. impingement test 100–14%	6 HO 1 24-h partial sciatic NP 3 THA
Byrd and Jones [28]	100	67/33	63/18/19	24	• mHHS ↑ 21.5 points	6 re-arthroscopies 1 transient pudendal NP 1 transient LCFN NP 1 mild HO
Javed and O'Donnell [29]	40	26/14	40/0/0	30 (12–54)	• mHHS ↑ 19.2 points • NAHS 15.0 points	7 THA
Philippon et al. [30]	65	17/34	10/15/75	42 (24–60)	• mHHS ↑ 34 points	8 rearthroscopies for capsulolabral adhesions
Palmer et al. [31]	201	99/102	152/0/49	46	• NAHS ↑ 22 points • VAS for pain 6.8–2.7 • Pincer resections had significantly poorer results	13 THA 1 superficial phlebitis 1 superficial infection 1 transient foot paresthesia 1 HO
Malviya et al. [32]	612	355/257	537/14/61	38.4 (12–84)	• QoL scores ↑ in 76.6%, unchanged in 14.4%, ↧ in 9.0% • Sign. predictors: preop. QoL score and gender • The lower the preop. score, the higher the gain in QoL postop	NR

mHHS modified harris hip Score, *HOS* hip outcome score, *NAHS* nonarthritic hip score, *NR* not reported, *QoL* quality of life, *SF-12* Short Form-12, *LCFN* lateral cutaneous femoral nerve, *THA* total hip arthroplasty, *VAS* visual analog scale, *NP* neuropraxia, *HO* heterotopic ossification

Key Points

- Interportal ***capsulotomies*** during central compartment exposure lead to reduced tension of the joint capsule with subsequent reduction of peripheral compartment visualization and should be avoided.
- The ***peripheral compartment first*** technique with direct exposure and resection of the Cam deformity is recommended.
- A comprehensive ***exposure*** of the peripheral compartment and Cam deformity is the prerequisite of a successful Cam resection.
- A ***ballooning technique*** with thinning of the zona orbicularis and selective capsular incisions is frequently sufficient for an adequate visualization.
- In most cases, a ***three-portal technique*** is required for a complete Cam resection. The proximal anterolateral portal is recommended for inspection, the anterolateral Cam deformity is resected via the anterior portal, whereas the posterolateral Cam is better accessed via the anterolateral or lateral portal.
- Resection of the Cam deformity needs to be performed ***without and with***

traction: The anterolateral part of the Cam can be resected without traction; for access to the posterolateral Cam, the head frequently needs to be distracted from the labrum and acetabular rim.

- During Cam resection, the hip needs to be ***moved*** into different degrees of flexion, rotation, and abduction to improve visualization of different areas of the head–neck junction, avoid damage of the femoral head cartilage, and confirm an impingement-free motion of the head within the acetabulum.
- A ***smooth transition*** from the convexity of the head to the concavity of the neck should be achieved.
- If orientation is difficult and visualization reduced, ***fluoroscopy*** should be used in order to confirm the correct extent and depth of Cam resection. In addition, an adequate Cam resection needs to be confirmed by fluoroscopy prior to evacuation of the joint.
- The end vessels of the ***medial circumflex artery*** entering the posterolateral head–neck junction need to be spared in order to avoid avascular necrosis of the femoral head.

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