Nicolas Bonin
Filippo Randelli
Vikas Khanduja
Editors

Hip Preservation Surgery

Open, Arthroscopic, and Endoscopic Techniques

European Society of Sports Traumatology, Knee Surgery & Arthroscopy
ESSKA

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Foreword

Hip preservation surgery has grown dramatically in the last decade. This is evident by the growth in research publications, organized societies that address the hip, and advanced courses in surgical intervention. Once thought of as a simple "ball and socket joint," the increased understanding of the mechanics of the hip joint as well as renewed interest in conditions that affect the hip has led to the development of new diagnostic and treatment strategies. With this growth in knowledge, there is not only an opportunity to help patients who seek our care but also the challenge of filtering through a vast amount of novel information. This process of determining what works and how in order to preserve the hip joint is critical to enhance our ability to provide beneficial treatment strategies. As such, a resource that provides a wealth of knowledge from expert clinicians based on contemporary techniques and sound clinical research is needed. This book, with input from such renowned experts, provides a resource that addresses conditions that affect the hip using strategies that are both open and arthroscopic for the purpose of long-term hip preservation. I congratulate all of the contributors from authors to editors on a job well done in completing such an important and comprehensive book on hip preservation surgery. This book will certainly educate clinicians and help advance patient care.

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Preface

In the era where Total Hip Replacement surgery is flourishing and there are so many other texts already existing on hip preservation surgery, another textbook on the same niche area may seem unnecessary by the vast majority of orthopedic surgeons.

However, we are three friends in different parts of Europe and despite Brexit had the same passion of educating on and advancing surgical techniques in hip preservation surgery, and were up for the challenge.

The challenge was to compile and edit a brand new textbook focusing mainly and specifically on the most practical and technical part of hip joint preservation, which is often a fairly demanding procedure. The focus was to make the text as concise as possible but at the same time be comprehensive about the pathology. The other objective was that the text should also include a lot of visual aids to help surgeons to actually understand the steps involved in the procedure and tips and tricks to make the procedure easier.

ESSKA, as a leader in arthroscopic and joint preservation surgery with a good track record of excellent titles in this arena, also needed to fill the gap in their portfolio as far as the hip joint was concerned and welcomed our initiative with open arms and enthusiasm and actioned it with due diligence. This and the excellent project management and editorial help from Springer are the main reasons as to why this multi-author text was ready in record time.

As you will see from the contents of the book, we have addressed all the pathologies and selected a terrific brigade of surgeons from the members of ESSKA Hip Committee and the most renowned key opinion leaders in hip preservation surgery from across Europe to help us with the chapters. The authors were allocated the topics based on their area of expertise and most importantly their passion for that particular pathology and surgical technique.

Each author has contributed immensely and has developed a product that has surpassed all our initial expectations—a deep dive into surgical techniques with tips and tricks, high quality photographs and videos, to help all of us and eventually for the betterment of our patients.

We are incredibly grateful to all our authors for their excellent contribution, Springer and all their staff especially Ms. Vinodhini Subramaniam for their project management and editorial help, ESSKA for believing in us and giving us this wonderful opportunity, and to all those involved in the realization of what we already jokingly call a “must-have” book.

It certainly has been *a labor of love* and we have had a great time in producing this book. We sincerely hope that you find it useful and enjoy it as much reading it as we have enjoyed producing it.

Lyon, France	Nicolas Bonin
Milan, Italy	Filippo Randelli
Cambridge, UK	Vikas Khanduja

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About the Editors

Nicolas Bonin, MD, MS, DESC is an orthopedic surgeon specializing in hip surgery and sports traumatology. He is a founding member of Lyon Ortho Clinic in Lyon, France, where he heads the Hip and Sports Medicine Unit. He gained his MD, master's degree in Biological and Medical Science, and DESC (Diplôme d'Études Spécialisées Complémentaires) from the Faculty of Medicine and Pharmacy in Besançon, in 2001, 2002, and 2004, respectively. He holds a Diploma in Arthroscopy from the Faculty of Medicine, Paris Ouest, and is now a training member of this diploma on behalf of the French Arthroscopy Society. Dr. Bonin is a member of the ISHA Board of Directors and participates in numerous hip committees for scientific societies (ESSKA, ISAKOS, SFA). He is the author of more than 30 original articles, many of which relate to the hip, as well as numerous book chapters.

Filippo Randelli, MD is an orthopedic surgeon specialized in hip and trauma surgery at Gaetano Pini -CTO Orthopedic Institute University of Milan. He graduated in Medicine from the University of Milan in 1996 and completed an AO Trauma Fellowship in Trauma at the Hospital for Special

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Vikas Khanduja, MA, MB BS, MSc, FRCS (Orth) is a Consultant Orthopedic Surgeon in the Department of Trauma and Orthopaedics, Addenbrooke's Hospital, Cambridge, UK. He is an Associate Lecturer in the Faculty of Clinical Medicine at the University of Cambridge and the Lead for Elective Clinical Trials. He has been instrumental in setting up the tertiary referral service for Young Adult Hip Surgery in Cambridge and has authored over 100 peer-reviewed articles and two books. He has won numerous awards, sits on the Board of Directors for SICOT as Chair of the Education Academy and the British Hip Society as the Chairman for the Non Arthroplasty Hip Register (NAHR), and is the Associate Editor of the *Bone and Joint Journal*.

Part I

Synovium

1

Joint Lavage, Synovectomy, Biopsy, and Loose Body Removal

Idriss Tourabaly and Thierry Boyer

1.1 Introduction

Hip arthroscopy is actually the best technique to treat synovial hip disease. Synovial pathologies are wide, but two diagnoses must be known by the hip surgeon: synovial chondromatosis [1–3] and villonodular synovitis [4–6]. These rare pathologies are developed from a metaplasia of synovial membrane. Young adult with mechanical hip pain with normal x-ray should be explored for synovial disease.

Synovial chondromatosis is a benign disorder characterized by cartilaginous nodules (chondromas) or secondary ossified chondromas when the pathology is more advanced (osteochondromas) [7]. There are two categories: primary osteochondromatosis and secondary osteochondromatosis in which cartilage and bone fragment are secondary to trauma or osteoarthritis. Those nodules can be embedded or pedunculated or become free loose bodies in the joint cavity. Most of the time, chondromas are localized in the peripheral compartment of the hip, particularly in the different synovial recess. However, the central compartment must be checked to assess chondral status and search for agglutinated chondromas under the fovea. The risk of recurrence depends on the stage of disease described by Milgram. When chondromas are totally free, it means that synovial is inactive with less risk of recurrence of chondromatosis. Prognosis is evaluated by cartilage injury and chondropathy. If the chondral status is acceptable, a re-arthroscopy can be proposed in the event of iterative chondromatosis. If the chondral lesions are too advanced, THA should be discussed [8].

Villonodular synovitis is a benign synovial proliferation [9, 10]. Two forms exist: localized form characterized by firm consistency nodule, sessile or pedunculated, with sometimes colored hemorrhagic staining, and diffuse form where we can see major hypertrophic synovial proliferation. Synovial takes villous or nodular aspect. Color of synovial is typically ocher or brown or red/brown stain. Risk of recurrence is high in diffuse form and depends of our ability to perform a total synovectomy. Diffuse form with associated chondropathy has low prognosis [11]. Risk of recurrence in diffuse form is up to 50%. At term, joint destruction needs THA.

Synovial pathologies are difficult to treat. Visualizing the different capsular recessus where synovial and free loose bodies can accumulate can be challenging.

It is important to take time for exposition to avoid iatrogenic injury. Patients are most of the time young, and preserving them from chondral iatrogenic lesion is fundamental. In rare cases, it could be less invasive to practice a little Hueter

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Electronic Supplementary Material The online version of this chapter (https://doi.org/10.1007/978-3-662-61186-9_1) contains supplementary material, which is available to authorized users.

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approach with assistance of arthroscopy to treat the central compartment [12–14].

Planning a surgical procedure with complete imaging improves the quality of synovectomy or helps to decide the best way to catch free loose bodies. For example, if joint is totally filled with hundreds of large diameter loose bodies, any cannulas or grasper will manage it, so it can be a good indication for a first open arthrotomy.

1.1.1 Arthroscopic Technique [15–18]

Addressing synovial pathology requires arthroscopic skills and some experience to explore all hip joint compartment safely without iatrogenic injury [19].

The setting in operating room is classic and depends on your own way to practice hip arthroscopy. It can be supine or lateral setup.

Approach can be through the central first technique with traction and use of fluoroscopy. The second technique is to use a peripheral first technique to access the two peripheral compartments (proximal and distal) without any traction and any fluoroscopy. We use this peripheral first technique in our daily practice. This technique was published in 2014 [17] (Fig. 1.1).

1.1.2 How to Visualize Medial Recessus?

Often, extensive synovitis or chondromas are localized in medial recessus. Access to this part is not common when we address femoral cam, for example.

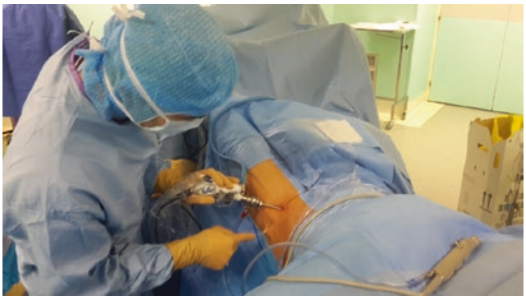

Fig. 1.1 Access to the peripheral compartment first without traction and without fluoroscopy

Fig. 1.2 Lots of ossified chondromas filling medial recessus seen on a TDM exam

A tip for all arthroscopic procedures is to switch portal and scope to improve exposition and have better visualization (Fig. 1.2).

Basically we use number 1 and number 4 portals to explore anterior and medial part of the joint. Portal numbers 2 and 3 are used only if visualization is not enough. Never pass through the medial side of the vertical line drawn from the ASIS (Figs. 1.3 and 1.4).

1.1.3 Instruments

Extractions of loose bodies don't need specific instruments but a variety of instruments to adapt to different situations. It depends on the size and shape of chondromas and location of those.

You can use the following:

- Different sizes of cannulas to extract free loose bodies by suction +++ (Fig. 1.5)
- Classical forceps (Fig. 1.6)
- Fragmentation
- Curved instrument to access foveal area
- Mega-graspers for big-sized chondromas (Fig. 1.7)

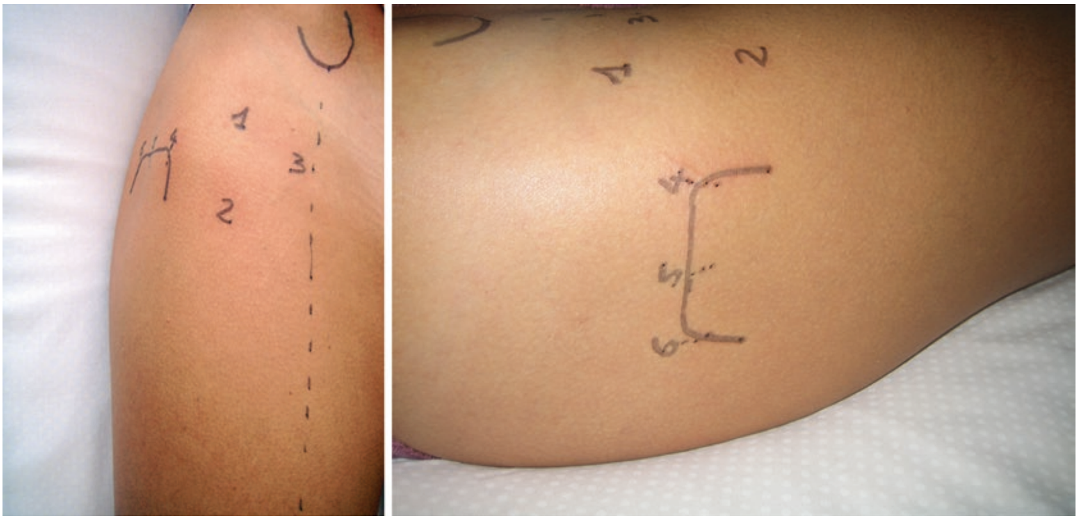

Fig. 1.3 Basic hip arthroscopic portal. Number 1 and 4 are often used

Fig. 1.4 The classical test with needle and nitinol guide is important to ensure you are inside the joint before introducing instruments

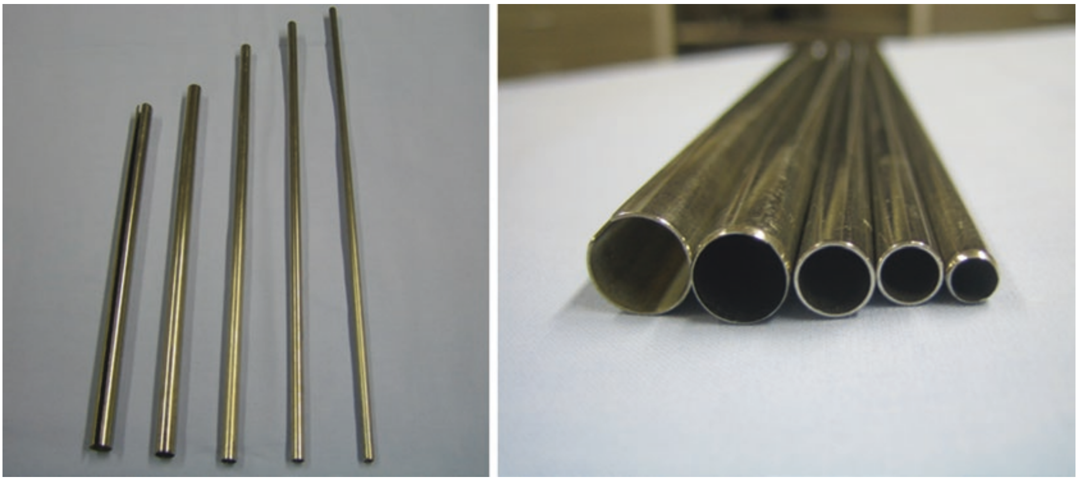

Fig. 1.5 Different sizes of cannulas

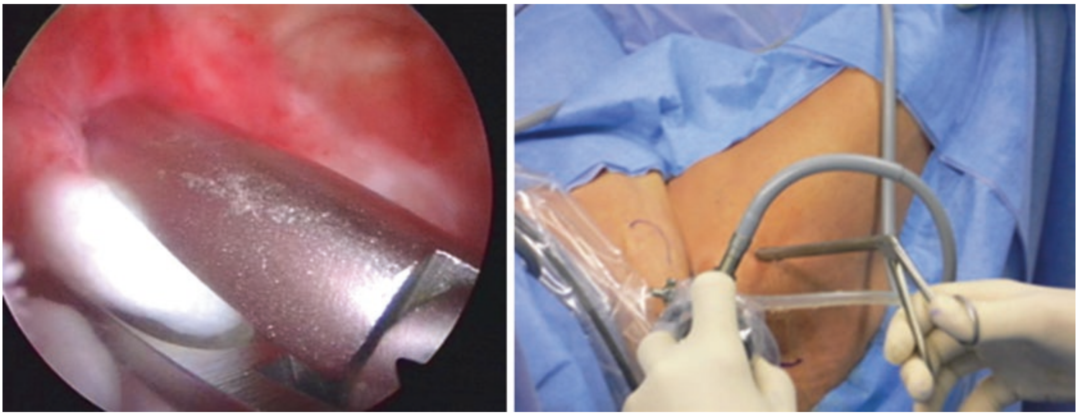

Fig. 1.6 Classical grasper for small- or medium-sized chondromas

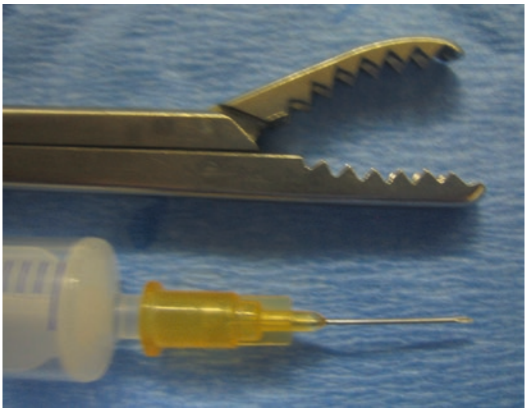

Fig. 1.7 Mega-grasper is useful to catch big chondromas

1.2 Villonodular Synovitis

Arthroscopic treatment of pigmented villonodular synovitis is similar for all synovial pathology. The more complete synovectomy will be practiced; the best result will be attempted. The quality of synovectomy is directly correlated to the risk of recurrence.

Incidence of villonodular synovitis is estimated around 1.8 cases per million persons per year [20, 21]. That is why only few reports with small cases are available related to arthroscopic procedure [11, 22–25].

Tips and Pearls for Synovectomy

How to enhance exposition when bleeding?

- Reduce blood pressure.
- Increase arthropump pressure temporarily.
- Put the scope close to the bleeding area.
- Be careful when synovectomy extends to the “posterior blind zone.”
- Do not forget to perform biopsies of the synovitis and around the lesion.

1.2.1 Synovectomy

It is important to take time to practice a large synovectomy [26–28]. This procedure could be difficult because of hemorrhagic suffusion inside the joint cavity. Reduced blood pressure can help, if possible for the anesthesiologist team. Temporarily increased arthropump pressure is also useful. Exposition is often enhanced when scope locates close to the bleeding area. Thus, it becomes easy to electrocoagulate a small hemorragia with radiofrequency probe.

Instruments that we will use for synovectomy are the shaver (straight or curved for the fossa) and radiofrequency probe (straight or curved).

Exploring the posterior part of cavity is important to assess extension of synovitis. Synovectomy of this “posterior zone” could injuried the blood supply of femoral head. In reality, complete synovectomy under arthroscopy remains impossible.

Last point is to perform several biopsies of the synovitis but also around the lesion for histologic analysis.

1.2.2 Diffuse Form of Villonodular Synovitis

Diffuse form of villonodular synovitis is difficult to treat [12]. Synovitis extends basically to all the joints. A total synovectomy is quite impossible to perform arthroscopically. However, arthroscopic procedure remains a less invasive technique if you take into account that open procedure in those cases is difficult too and increases probability of comorbidity (Figs. 1.8, 1.9, 1.10, and 1.11).

1.2.3 Nodular Form of Villonodular Synovitis

When a nodular form of villonodular synovitis is identified, an arthroscopic procedure can definitely heal your patient (Figs. 1.12 and 1.13).

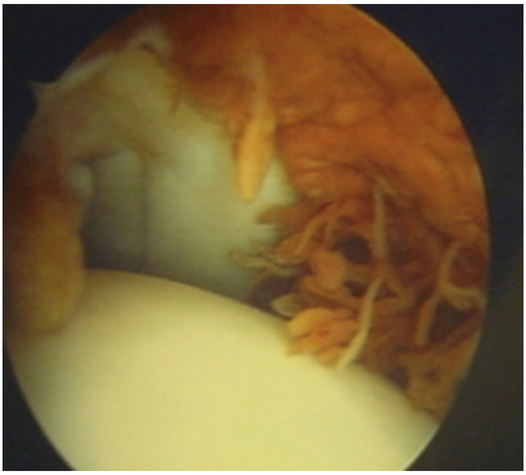

Fig. 1.8 A typical diffuse form of villonodular synovitis in the peripheral compartment

1.3 Chondromatosis

Synovial chondromatosis is difficult to treat because it requires a total synovectomy for embedded or pedunculated chondromas [22, 29]. The risk concerns injury of the blood supply to femoral head if synovectomy extends to the posterosuperior head-neck junction [30, 31].

In order to extract maximum of chondromas, high-quality imaging (X-ray, arthro-CT, MRI) helps to plan preoperatively the procedure.

1.3.1 Size and Shape of Chondromas

Small-sized and free chondromas are the easiest cases. We can extract all the loose bodies with cannulas and suction (Figs. 1.14 and 1.15).

Sometimes, chondromas can hide in the different joint recessus. Moving and shaking your patient leg can reveal new free loose bodies. Another tip is to add a flush by temporarily increasing pressure of arthropump (Fig. 1.16).

When chondromas are bigger, mega-grasper is useful. Be careful that chondromas don’t escape with a classical grasper. We can lose them into soft tissue between the capsula and skin. Some cases of secondary extra-capsular proliferation are described.

Therefore, enlarging the capsulotomy beside the portal with shaver, knife, or radiofrequency probe could facilitate the extraction of big loose bodies. You can even fragment large chondromas or ossified chondromas with a shaver or a burr before extracting them (Fig. 1.17).

1.3.2 Loose Body Location

You can find free loose bodies in peripheral compartment (most of the time) or in central compartment or both of them (Figs. 1.18 and 1.19).

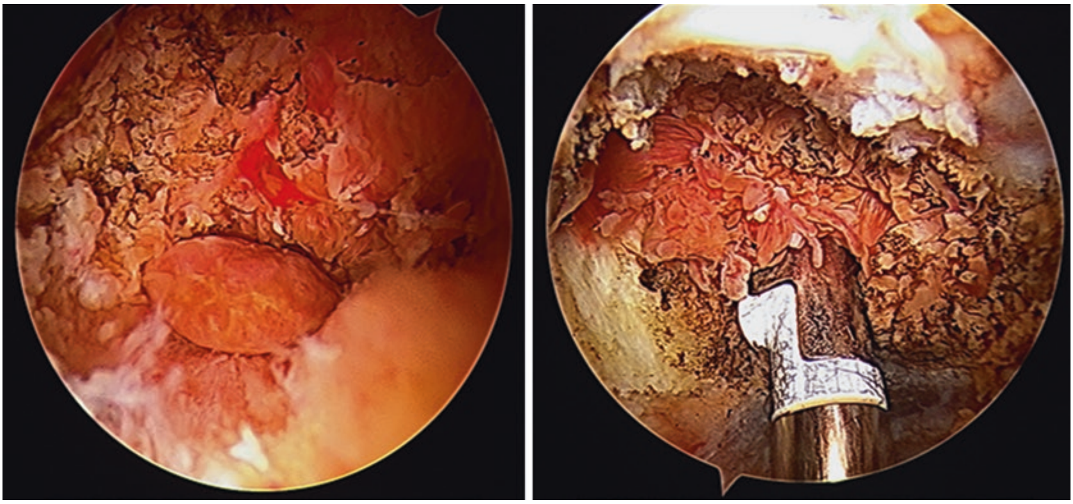

Fig. 1.9 Another diffuse form in peripheral compartment treated by electrocoagulation probe

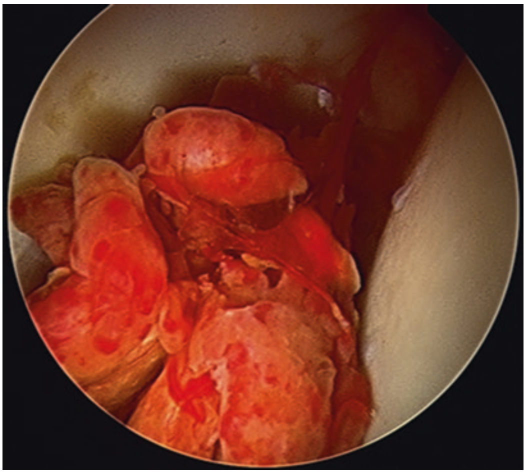

Fig. 1.10 A large villonodular synovitis in the central compartment filling acetabular fovea

1.3.3 Type of Chondromatosis

Chondromas can be declined in three categories: free foreign bodies, attached intra-synovial chondromas and integrated intra-synovial chondromas (Fig. 1.20).

Intra-synovial chondromas are challenging cases. Extracting all chondromas is difficult and requires total synovectomy. Access to embedded lesions is sometimes technically impossible (Fig. 1.21).

1.3.4 Managing the Peripheral Compartment

Catching free loose body could sometimes be difficult because chondromas move and can hide in capsular recessus. Doing a complete evaluation of the joint is important, particularly in the medial recessus and the posterior recessus (Fig. 1.22).

1.3.5 The Central Compartment (Fig. 1.23)

It is important to always screen all the central compartments to find free chondromas.

Do not hesitate to adapt your portal to have a better exposition of your chondromas (Figs. 1.24, 1.25, and 1.26).

Tips and Pearls for Loose Body Removal and Joint Lavage

How to find, catch, and extract free loose bodies?

- Move and shake your patient leg.
- Increase arthropump pressure temporarily.
- Switch portal and scope.
- Stop irrigating the joint before grasping.
- Large chondromas can be fragmented by a shaver or a burr.
- Enlarge the capsulotomy beside the portal to extract big chondromas.

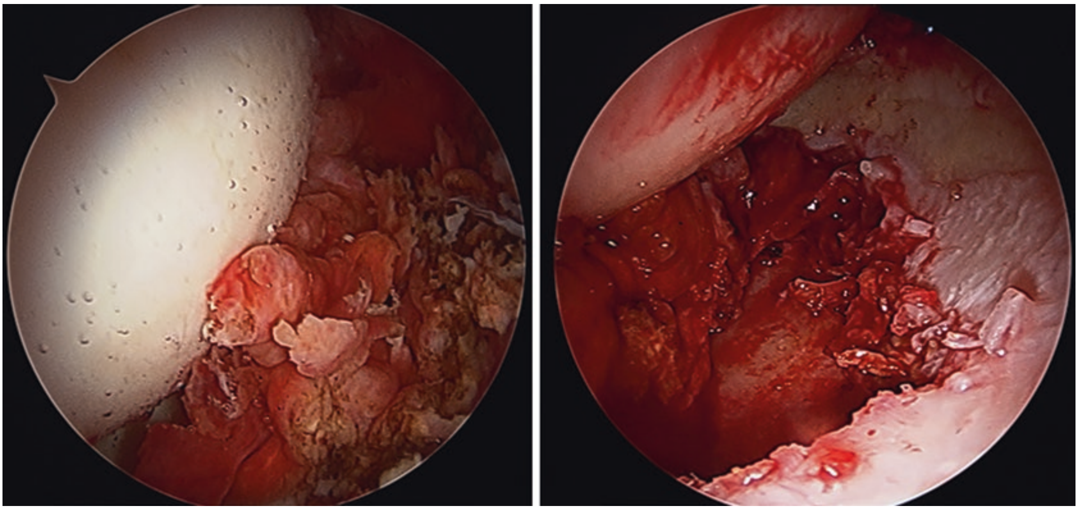

Fig. 1.11 Central compartment synovitis in fovea. Sometimes access to all parts of the fossa can be challenging even with curved instrument. Be careful not to create iatrogenic lesion on femoral head cartilage

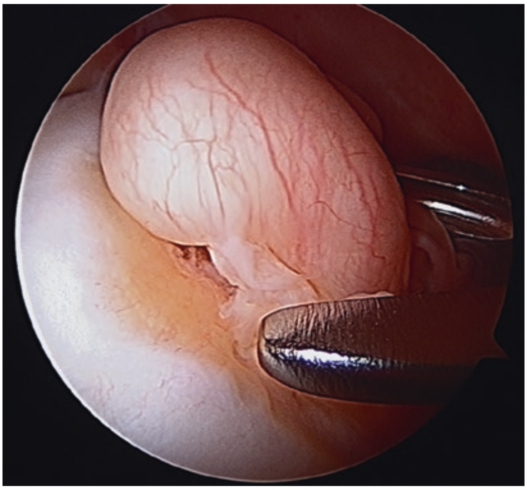

Fig. 1.12 A nodular form of villonodular synovitis in the peripheral compartment

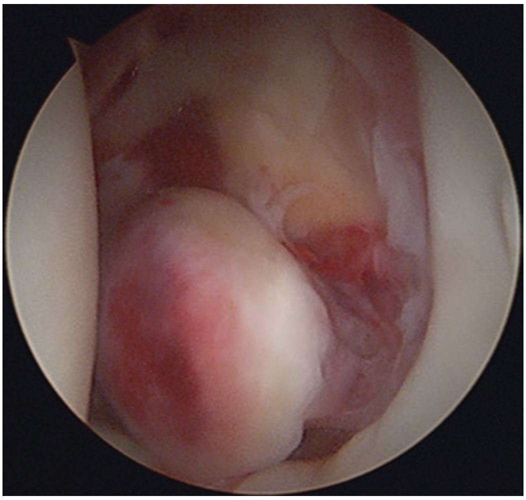

Fig. 1.13 Isolated villonodular nodule in the central compartment

Fig. 1.14 Free loose bodies on right hip artho-CT coronal view

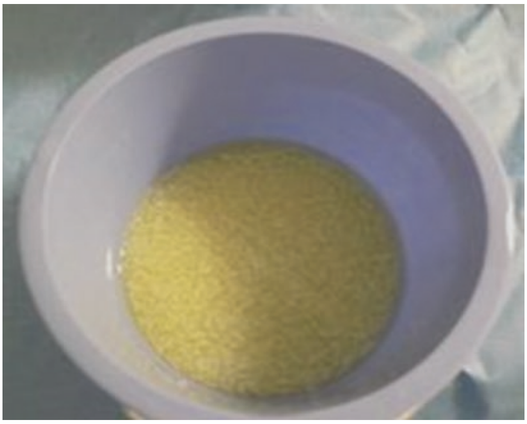

Fig. 1.15 Hundreds of free chondromas extracted by hip arthroscopy

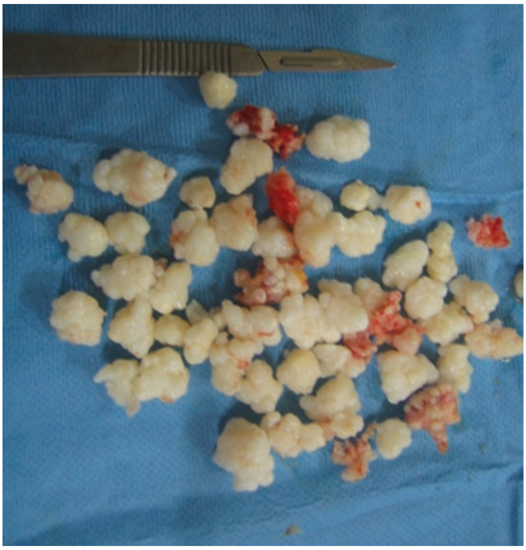

Fig. 1.16 Medium-sized chondromas

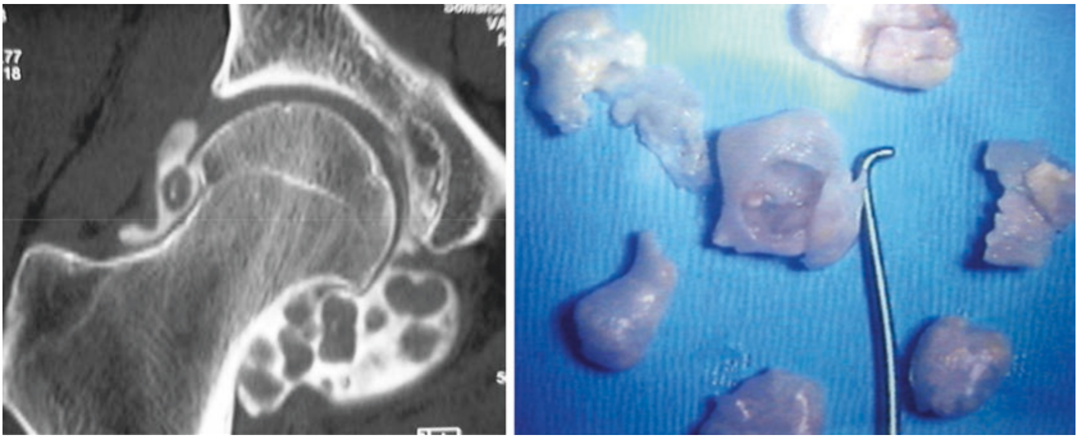

Fig. 1.17 Big-sized chondromas extracted by an arthroscopic procedure. It could be rational to consider an open arthrotomy for these difficult cases

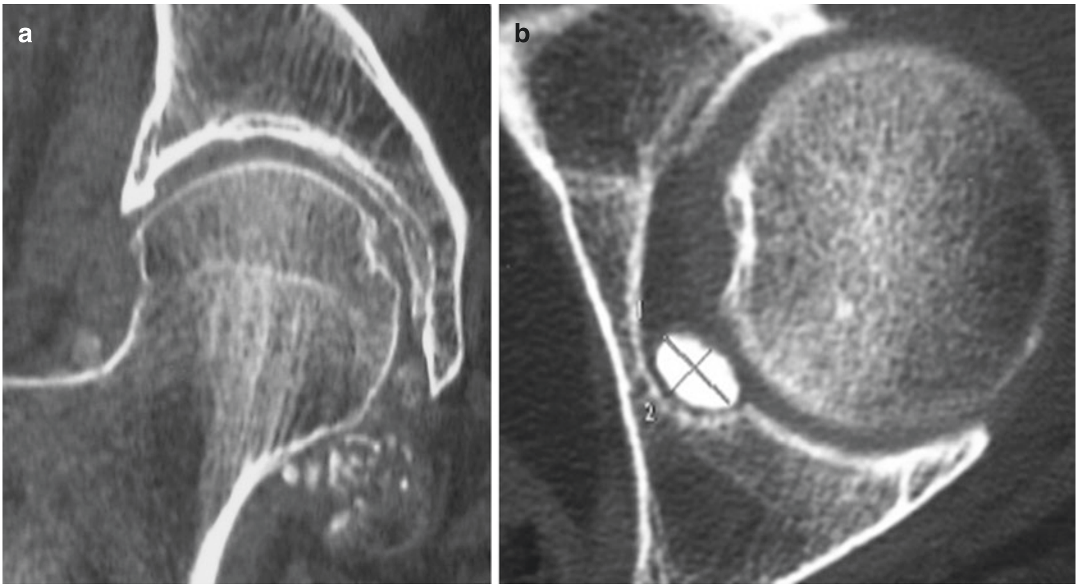

Fig. 1.18 (**a**) Multiple localizations of osteochondromas in peripheral compartment on coronal TDM view. (**b**) Unique ossified chondroma in acetabular fossa on axial TDM view

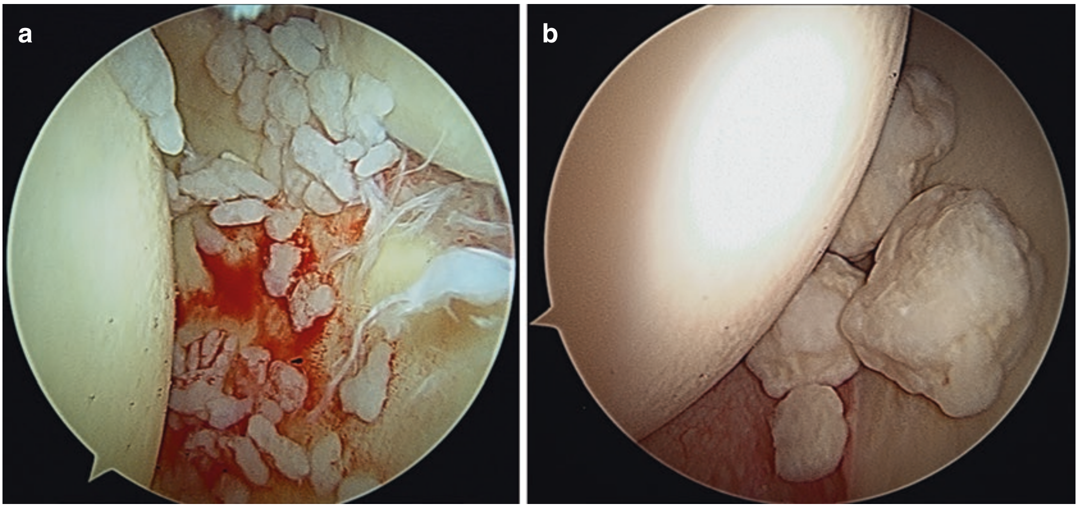

Fig. 1.19 (**a**) Multiple chondromas in fovea on arthroscopic view. (**b**) Four free loose bodies localize in the central compartment near the posterior acetabular rim

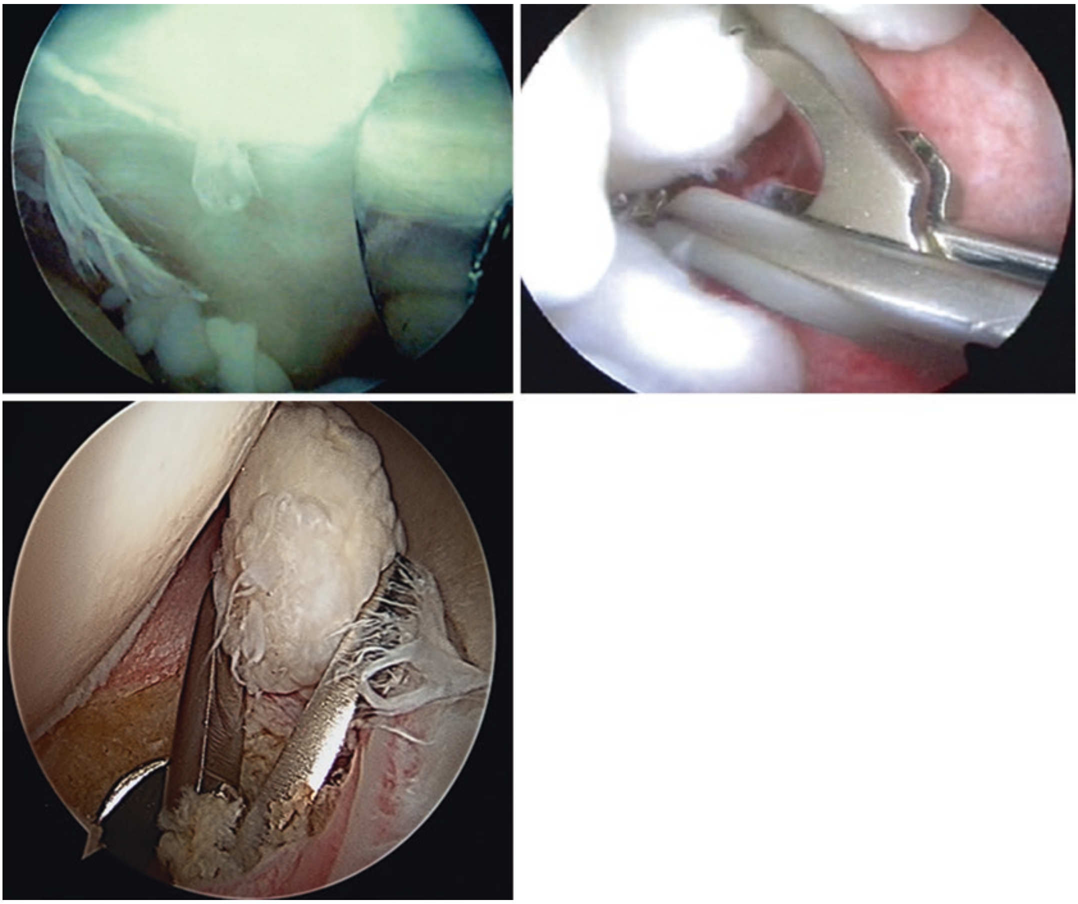

Fig. 1.20 Free chondromas are quite easy to extract with suction and different sizes of cannulas or grasper

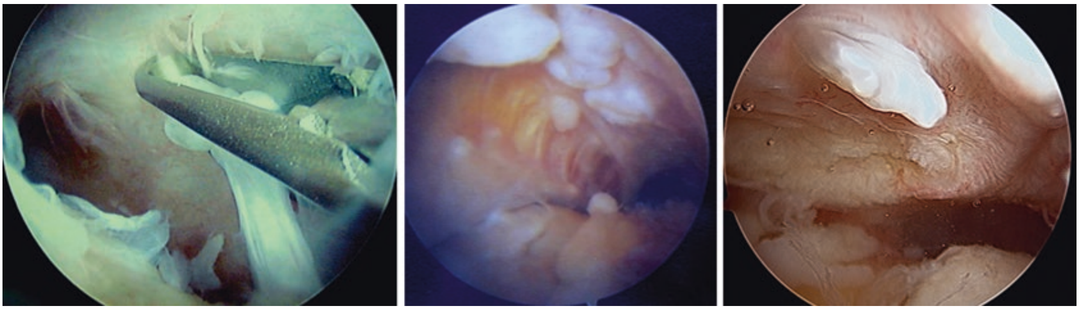

Fig. 1.21 Intra-synovial chondromas (attached and embedded)

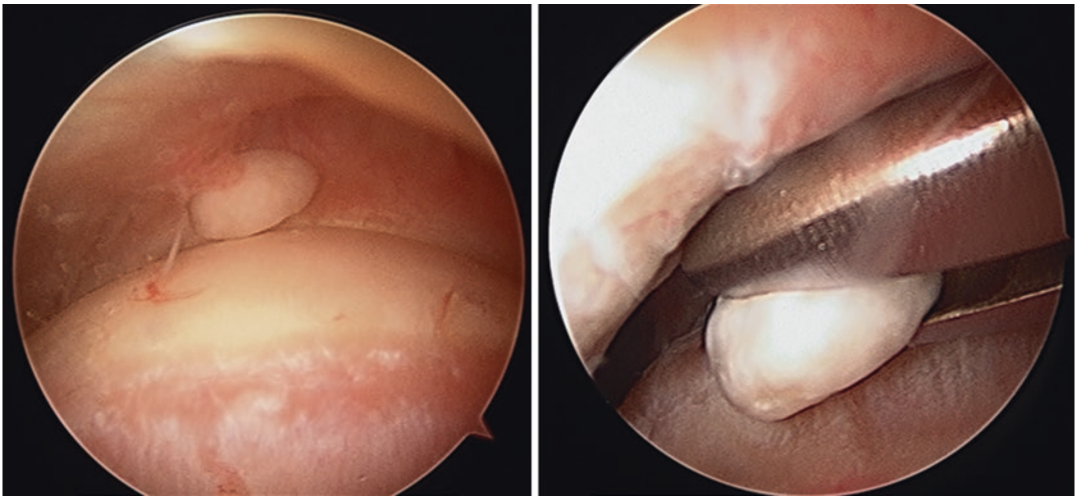

Fig. 1.22 You can stop irrigating the joint when you arrive with your grasper. It can facilitate grasping procedure

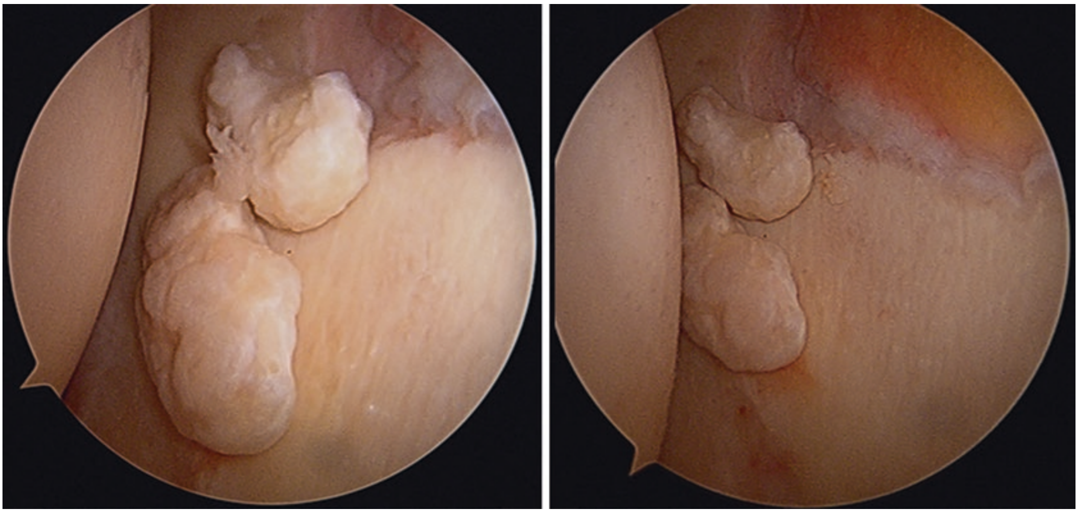

Fig. 1.23 Most of the time chondromas are waiting near the posterior acetabulum rim

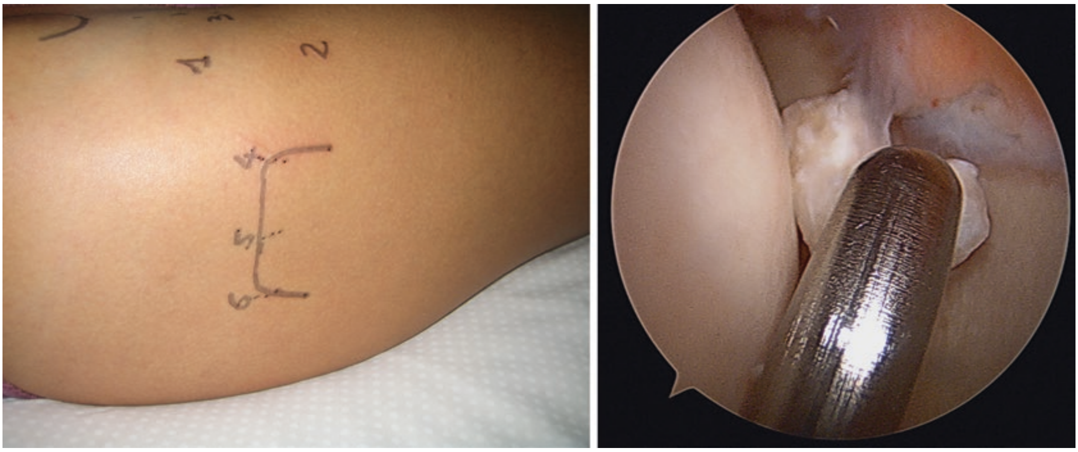

Fig. 1.24 For this posterior chondroma in the central compartment, performing an instrumental number 5 or 6 portal facilitated access to chondromas without risk of cartilage injury

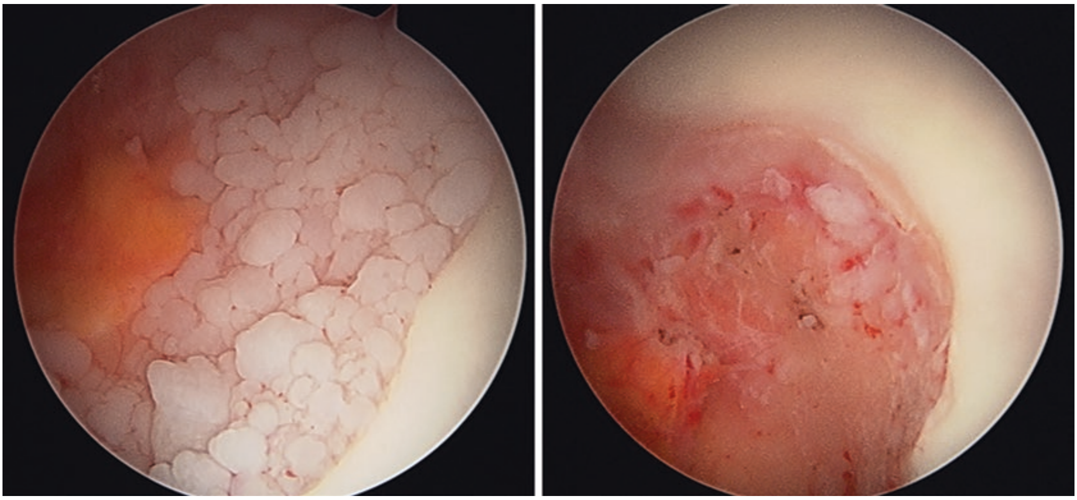

Fig. 1.25 A case of lots of chondromas waiting in the acetabular fovea (before and after extraction)

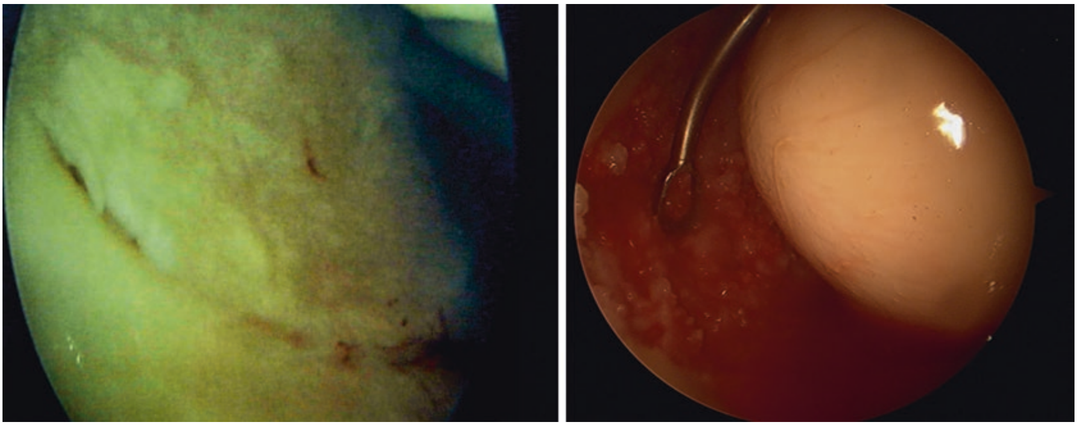

Fig. 1.26 Chondromas in the fovea can be hard to extract if they are not free. In case they agglutinate, they can form a "pancake." Using curved "curette" can help

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2

Painful Hip Arthroplasty Assessment: Removal of Cement or Loose Bodies

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2.1 Introduction

Traditional indications for hip arthroscopy are in the field of hip preservation surgery [1–3], but recently its use has been proposed in patients who have hip replacement (total hip arthroplasty [THA], hemiarthroplasty, or hip resurfacing). The concept of arthroscopy in a patient with joint replacement is not new [4], and had been used in patients with a painful knee and shoulder arthroplasties [5–9].

2.2 The Painful Joint Replacement

Despite its good results, groin pain after THA has been evaluated between 0.4 and 8.3% [10, 11]. Hip arthroscopy might be useful in both diagnosis and treatment of problems related to THA (Fig. 2.1), but its usefulness should not be overemphasized.

Groin pain after total hip arthroplasty has a prevalence ranging from 0.4 to 18.3% [12]. Usefulness of hip arthroscopy as a tool in groin pain after hip replacement should be based on a previous investigation of the causes of groin pain in these patients. With increase in number of total hip arthroplasties in young age group and increasing life expectancy, the number of patients with unexplained pain in a clinically and radiological sound hip is set to rise as well.

We could divide causes of groin pain after hip replacement as extrinsic and intrinsic [13] (Table 2.1).

Initially, individualized protocol (including physical exams, lab tests, imaging studies, joint aspiration) should be performed to rule out all these diagnostic options. Nevertheless, some patients with equivocal results of these investigations are classified as “diagnostic dilemma.” Arthroscopy could be indicated in such patients as a diagnostic tool and, eventually, a pain-relieving method. However, most cases of painful hip replacement require open revision arthroplasty surgery.

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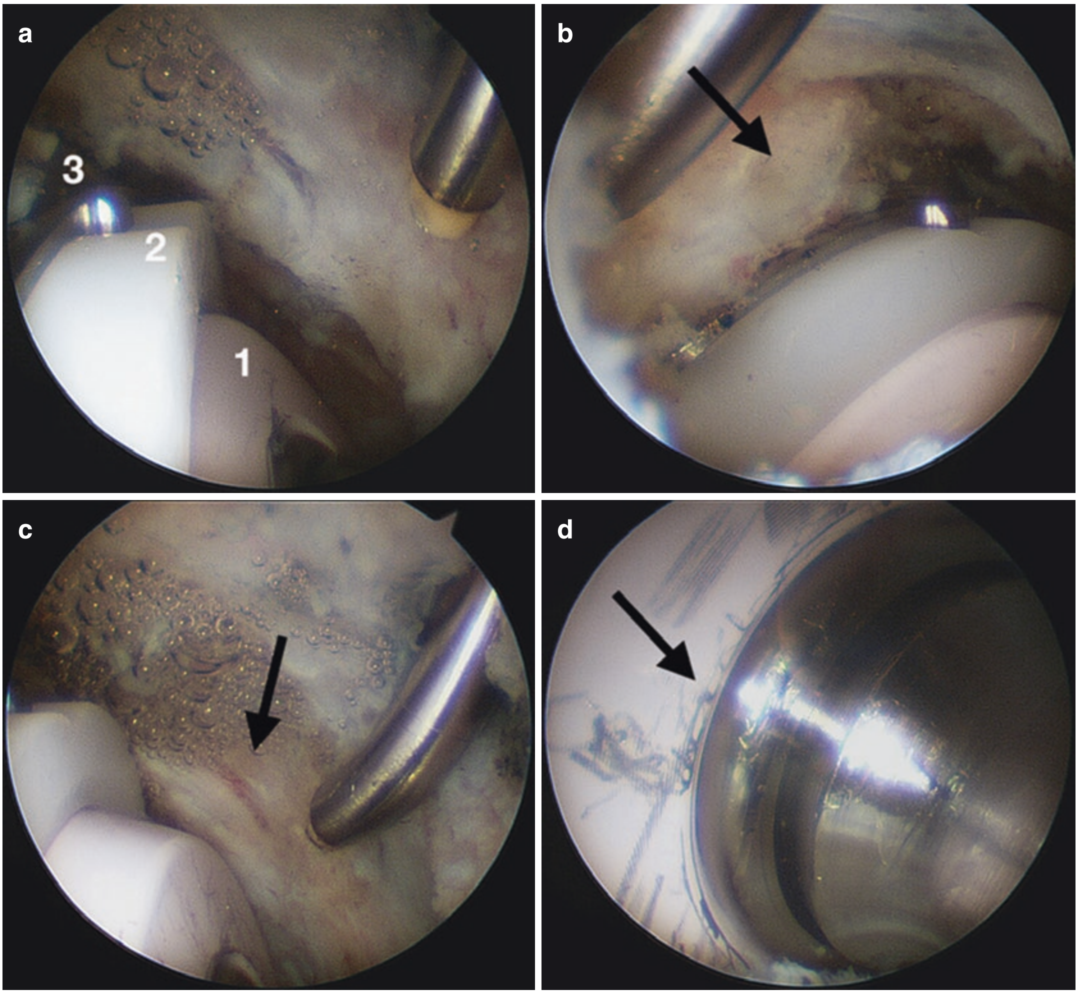

Fig. 2.1 Assessment of a painful THA. (**a**) Visualization of the polyethylene liner locking mechanism and metal back (1–3). (**b**) Checking impingement between bone acetabulum and implant. (**c**) Psoas redness. (**d**) Checking the femoral head and taper of the stem

Table 2.1 Etiologies of painful hip replacement

Extrinsic causes	Intrinsic causes
Great trochanter pain syndrome Local neurological/vascular pathology Heterotopic ossification Inguinal hernia Metastatic cancer Spinal pathology and radiculopathy	THA infection Aseptic loosening Iliopsoas tendonitis Impingement Synovitis metal/polyethylene debris Pelvic osteolysis Occult acetabular or pelvic fracture

2.3 Indications for Hip Arthroscopy in THA

Hip arthroscopy allows good visualization of the component surfaces, the adjacent synovium, and the surrounding soft-tissue structures (Iliopsoas tendon, reflected head of rectus femoris tendon, and hip capsule). Arthroscopy also enables dynamic assessment of hip anatomy and motion,

Table 2.2 Frequent indications of hip arthroscopy in painful hip replacement and its role in these pathologies

Hip arthroscopy indication	Role of hip arthroscopy
Psoas tendinopathy	Psoas release
Unknown painful hip replacement	Diagnosis and treatment
Periprosthetic THA infection	Diagnosis and treatment
Great trochanter pain syndrome	Debridement/tendon repair
Intra-articular bodies	Removal
Adhesions	Debridement
Chronic synovitis	Debridement/biopsy
Bone spur acetabulum or neck	Resection
Wear, component loosening	Diagnosis/dynamic assessment

allowing the surgeon to assess subtle residual impingement or component loosening.

Principal indications of hip arthroscopy affecting THA are well described in current literature [14–17] (Table 2.2).

In a systematic review, authors concluded that hip arthroscopy could be a safe and effective method to treat hip arthroplasty patients with iliopsoas tendinopathy and as a diagnostic tool for painful hip arthroplasty with no obvious diagnosis. Iliopsoas tendinopathy was the main indication (35.8%) followed by unknown painful THA (24.6%), periprosthetic infection (6.4%), and intra-articular loose bodies (3.5%) [18]. Several small individual series described hip arthroscopy as a useful tool after painful THA. Diagnostic proposal was described in 11 out of 16 cases in one series [19]. After hip arthroscopy was done, 9 out of 11 had synovitis and scar tissue that was debrided and 2 underwent open surgery for THA revision. Overall, arthroscopy effectively treated 8 out of 12 cases presenting as diagnostic dilemmas. In another publication, soft-tissue release was performed in 11 patients (iliopsoas tenotomy and debridement scar tissue). At 2 years, better results were detected in patients with arthroscopic iliopsoas tenotomy [20]. In a report of five patients with painful THA, two patients presented THA infection, two cases psoas tenotomy, and in two subjects with synovitis and adhesions a debridement was done [21].

In a large study over 24 painful hip replacements, preoperative provisional diagnoses were reached in 12 patients. Arthroscopy led to correction of the diagnosis in 4 of these 12 patients. In 12 patients who lacked a provisional diagnosis, hip arthroscopy established a diagnosis in 11. Overall, arthroscopy led to a new or corrected diagnosis in 15 of the 24 patients. They concluded that hip arthroscopy in a patient who remains symptomatic following joint replacement can be undertaken safely [14].

2.4 Surgical Technique

Regarding surgical technique, steps of arthroscopy in total hip replacement are similar to conventional hip arthroscopy. However, the use of traction is a matter of debate and it is unclear how much traction to use, at what position, and what is the safe time for traction (Fig. 2.2).

The portals are similar to traditional portals and are performed according to the surgeon preference. First portal, usually anterolateral, should be performed under fluoroscopy guidance to avoid prosthesis damage. Second portal is then constructed with direct visualization after connection of irrigation system (Fig. 2.3).

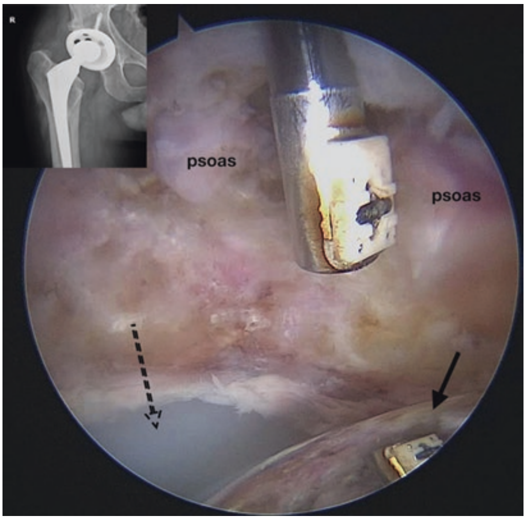

Fig. 2.2 Slight traction should be used to evaluate metallic femoral head (black arrow) and polyethylene liner (slotted arrow)

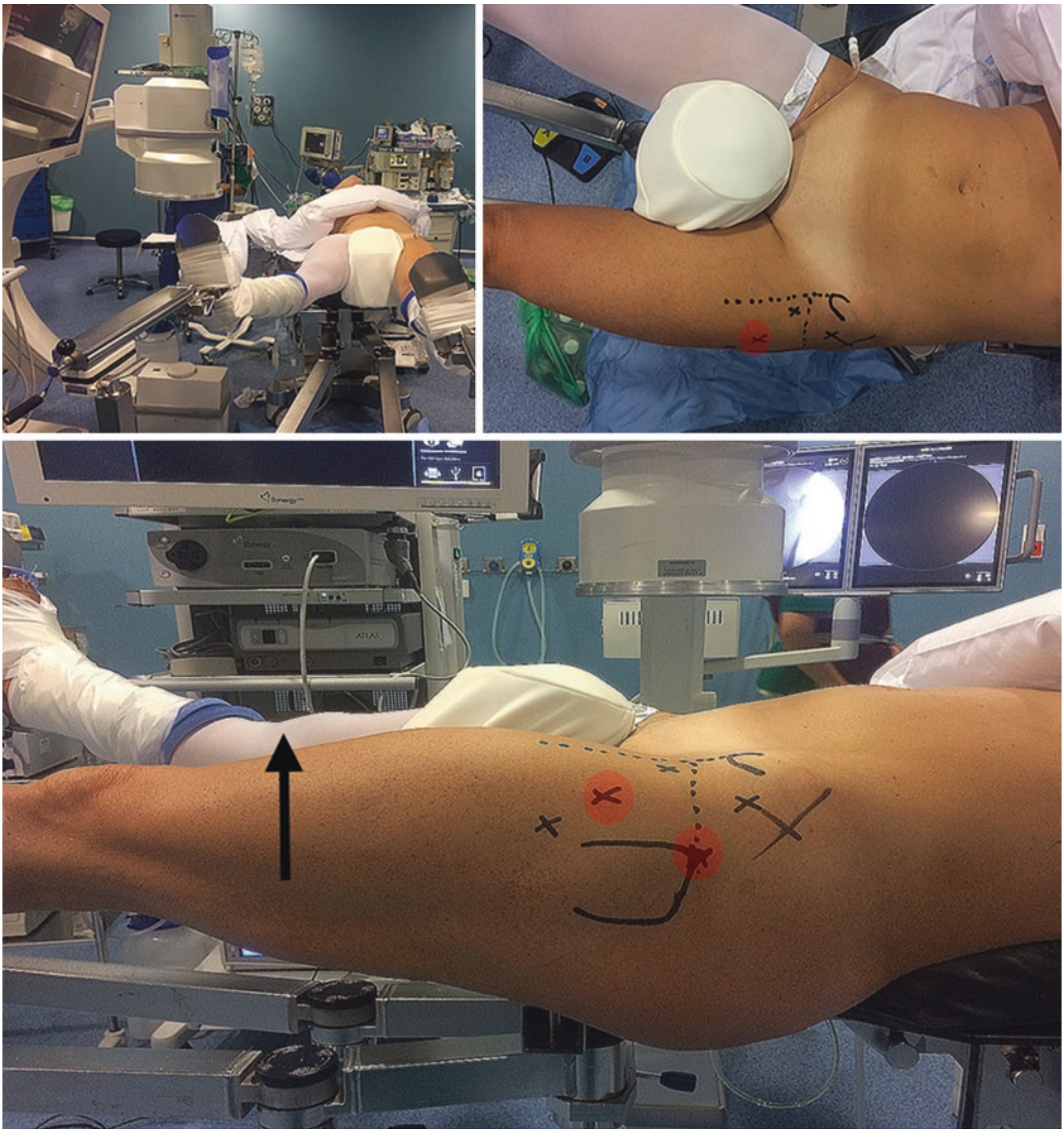

Fig. 2.3 Patient's position and standard portals. Standard anterolateral and distal anterolateral portals could be used. Slight flexion should be applied in case of transcapsular psoas tenotomy

Difficulty regarding arthroscopy in patients with total hip replacement cannot be underestimated. Challenges related to the learning curve of arthroscopy in native hips are well documented [22]. The complexity and difficulty increases in the presence of the hip prosthesis, mainly due to difficulty in performing traction, presence of scar tissue, and alteration of joint contour caused by prosthesis itself. One paper described the difficult access to hip joint during arthroscopic treatment of infected THA. Three hips out of five cases needed fluoroscopic guidance because of thick pseudocapsule causing significant resistance to penetration [23] (Fig. 2.4). Therefore, this procedure should be performed only by experienced surgeons and in well-equipped centers to deal with potential complications safely. Complications can occur in 3.2% of cases and include intraoperative breakdown of instruments, prosthetic instability, fluid extravasation into abdominal cavity, and heterotopic ossification [18].

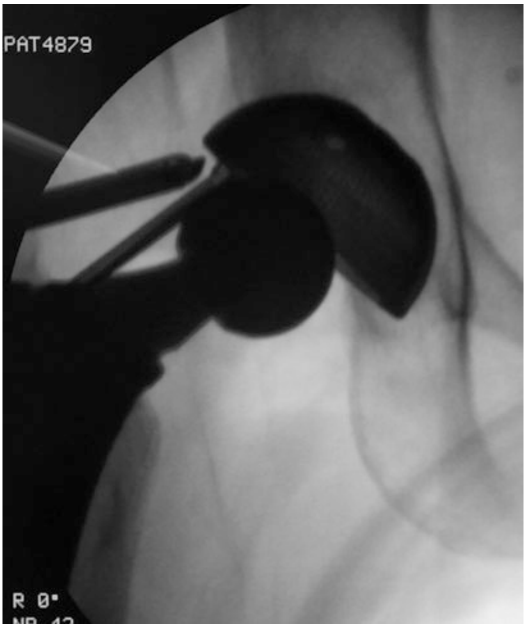

Fig. 2.4 Fluoroscopic guidance during hip arthroscopy in THA

Tips and Tricks

- Hip arthroscopy in painful THA could be a challenge. Surgeon should be experienced in hip arthroscopy before beginning with this indication.
- No traction or slight traction could be enough.
- Use your standard portals.
- Get the assistance of intraoperative fluoroscopy.

2.5 THA Infection

2.5.1 Diagnosis

The role of arthroscopy in treatment of infections is unclear. The value of arthroscopic tissue biopsy for detection and evaluation of an infection of THA even with a sterile aspirate has been proven [23]. Synovial fluid analysis is sometimes the only diagnostic determinant of low-grade chronic infection [24]. However diagnostic joint aspiration is often not as effective or successful, as sometimes it is impossible to procure enough samples for cytology and histopathology. Hip arthroscopy offers an opportunity to visualize the implants, and harvest synovial and periprosthetic tissue as well as synovial fluid. The diagnostic accuracy of arthroscopic biopsy in periprosthetic hip infections was evaluated in a retrospective study of 20 patients who underwent percutaneous aspiration as well as arthroscopic biopsy for suspected THA infection. Greatest diagnostic value was observed and arthroscopic biopsy was superior to erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), joint aspiration, and their combinations [25].

2.5.2 Treatment

Open arthrotomy and debridement remain the standard and first choice treatments for the acutely infected hip arthroplasty. A massive debridement, absence of loosening signs, a pathogen isolated sensitive to antibiotics, and high patient compliance to a long antibiotic treatment are essential elements for the hip arthroscopy indication in infections following THA [23].

Although arthroscopy is well documented in management of periprosthetic total knee arthroplasty (TKA) infections [26, 27], only few studies have been published for infected THA.

One study proposed arthroscopic irrigation and debridement for late periprosthetic THA infection. Following arthroscopic debridement, patients were treated with parenteral antibiotics for 2–6 weeks, followed by oral therapy. There was no recurrence of infection and no progressive radiographic loosening at an average follow-up of 70 months. Recurrence assessment was made only on the basis of clinical examination [23]. To our knowledge, no other study reproduced these findings in the literature. A different study proposed arthroscopic biopsy, lavage (9–12 L of saline), and debridement. Antibiotics were given intravenously according to culture followed by lifelong oral antibiotic suppression. There was no recurrence of infection at mean 70 months of follow-up. The authors suggested that arthroscopic irrigation and debridement could be of benefit for appropriately chosen patients who suffer late, acute infections with well-fixed total hip replacement [23]. Lahner et al. reported results on five patients with persistent hip pain after surgery. Hip aspirations were negative for all of them. In two cases, low-grade infection was detected after long-term incubation. One of them underwent revision and the other was treated with long-term antibiotics [21]. In a study over 16 hip arthroscopies in patients with unexplained painful THA, one patient was diagnosed of infection not confirmed by standard tests. Another patient with sepsis was not a candidate for open arthrotomy and was treated with irrigation, arthroscopic debridement, and intravenous antibiotics without recurrence at last follow-up [19].

Tips and Tricks

- Hip arthroscopy, performed by experience surgeons, could be helpful in diagnosis of THA infection.
- Take several samples from different suspected type of tissues.
- In low-grade infection, lavaging with more than 9 L of saline and extensive debridement could be an option.

2.6 Intra-articular Loose Bodies

The removal of foreign bodies and entrapped cement using arthroscopic techniques has been previously reported after hip arthroplasty in different case reports [17, 28–30]. In these cases, dislocations of hip implants in either the perioperative period or later resulted in entrapment of the implanted drain or fragmented cement debris, preventing successful closed reduction. Hip arthroscopy was successfully used to clear the interposed material and enable closed reduction of the hip prosthesis. However, hip arthroscopy in these cases is useful but not definitive, and the surgeon often proceeds to implant revision.

Vakili et al. [30] reported three cases in which a foreign body was found entrapped within the acetabular component after total hip replacement. Traction was needed to arthroscopically remove two fragments of acrylic cement between prosthetic head and acetabular cup preventing adequate reduction. Arthroscopic removal of broken trochanteric wires and cement debris from a dislocated total hip replacement was also published. Hip arthroscopy allowed visualizing that both the acetabular cup and the femoral head were not scuffed or damaged [29]. It was also suggested a dynamic inspection of the joint to assess stability after arthroscopic removal of a cement fragment [30].

Arthroscopic assessment of polyethylene wear or component mobilization could also be done when component loosening is suspected [16, 17].

Not only cement loose bodies have been described, but also removal of metallic loose bodies in patients with THA has been published. Unfortunately, this procedure may not be definitive and patient may need component revision in some cases [19].

Tips and Tricks

- Loose body removal in THA (cement or other materials) could be really difficult.
- Location of the fragments preoperatively could be useful but be aware of mobile loose bodies.
- Peripheral compartment must be always assessed, as many mobile fragments usually are located at this compartment.
- Postero-lateral portal could be necessary in some cases.

2.7 Adhesions and Reactive Synovitis in MoM THA

Adhesions and reactive synovitis may cause persistent inguinal pain that does not respond to conservative treatment. Good clinical improvement has been reported for patients treated for periprosthetic adhesions with hip arthroscopy [20].

However, a literature review disagrees about this topic, probably on the correlation between adhesions and metal hypersensitivity reaction or

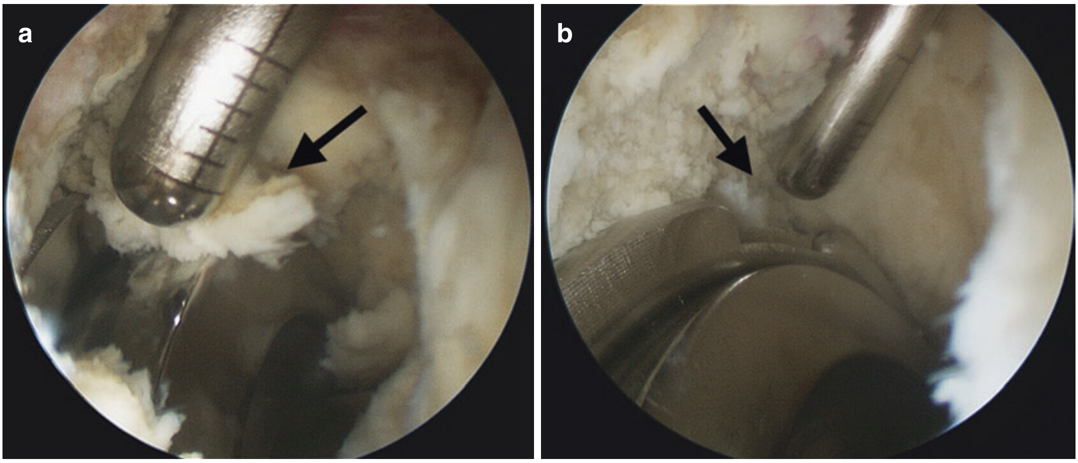

Fig. 2.5 Groin pain in a patient with metal-on-metal THA with big femoral head. (**a**) Intense soft-tissue proliferation and synovitis. (**b**) Debridement and biopsy of soft tissue

particle debris reaction in metal-on-metal (MoM) THA. Metal sensitivity, as the source of groin pain, should be considered when other causes of pain and/or joint effusion in hips with MoM THA have been ruled out [31]. Arthroscopically obtained synovial biopsies might help to establish the diagnosis of metal sensitivity [32]. According to Zustin et al., proliferative desquamative synovitis is another morphologic feature associated with the delayed-type hypersensitivity reaction [33]. In a cohort of patients with chronic inguinal pain after THA with no signs of aseptic loosening or infection, an extensive arthroscopic debridement was done. After the procedure, 55% were pan free, patients presented complete resolution of symptoms, 22% patients required component revision, and 11% needed an open iliopsoas tenotomy [19] (Fig. 2.5).

Tips and Tricks

- Adhesion debridement should be associated with synovial biopsy to rule out metal hypersensitivity reaction.
- Component loosening should be tested intraoperatively.
- Iliopsoas impingement must be ruled out under direct visualization.

2.8 Role of Arthroscopy in Resurfacing Hip Arthroplasty

Persistent groin pain after resurfacing arthroplasty can be multifactorial. Incidence can be as high as 18%. Overall, painful hip resurfacing comes from insufficient head–neck ratio causing impingement, or uncovered acetabular component causing friction on iliopsoas tendon. Up to 5% of patients with hip resurfacing have iliopsoas tendinopathy caused by prominent acetabular cup [34]. Impingement after resurfacing arthroplasty has been related to anterior femoral neck bone prominence (Fig. 2.6) and component malposition (retroverted acetabulum, posterior translation, and anterior angulation of femoral implant) [32].

However, some painful resurfacing patients appear without presence of an identifiable cause. Some studies suggest that hip arthroscopy can be a useful diagnostic and therapeutic tool, and may even prevent an arthroplasty revision [14, 35]. However, in a cohort of hip resurfacing patients with groin pain, hip arthroscopy was considered useful only as a diagnostic tool, but not as a treatment option [35]. Nevertheless, the role of hip arthroscopy as a treatment option has been supported by several publications when a correct diagnosis is established. Arthroscopic treatment might

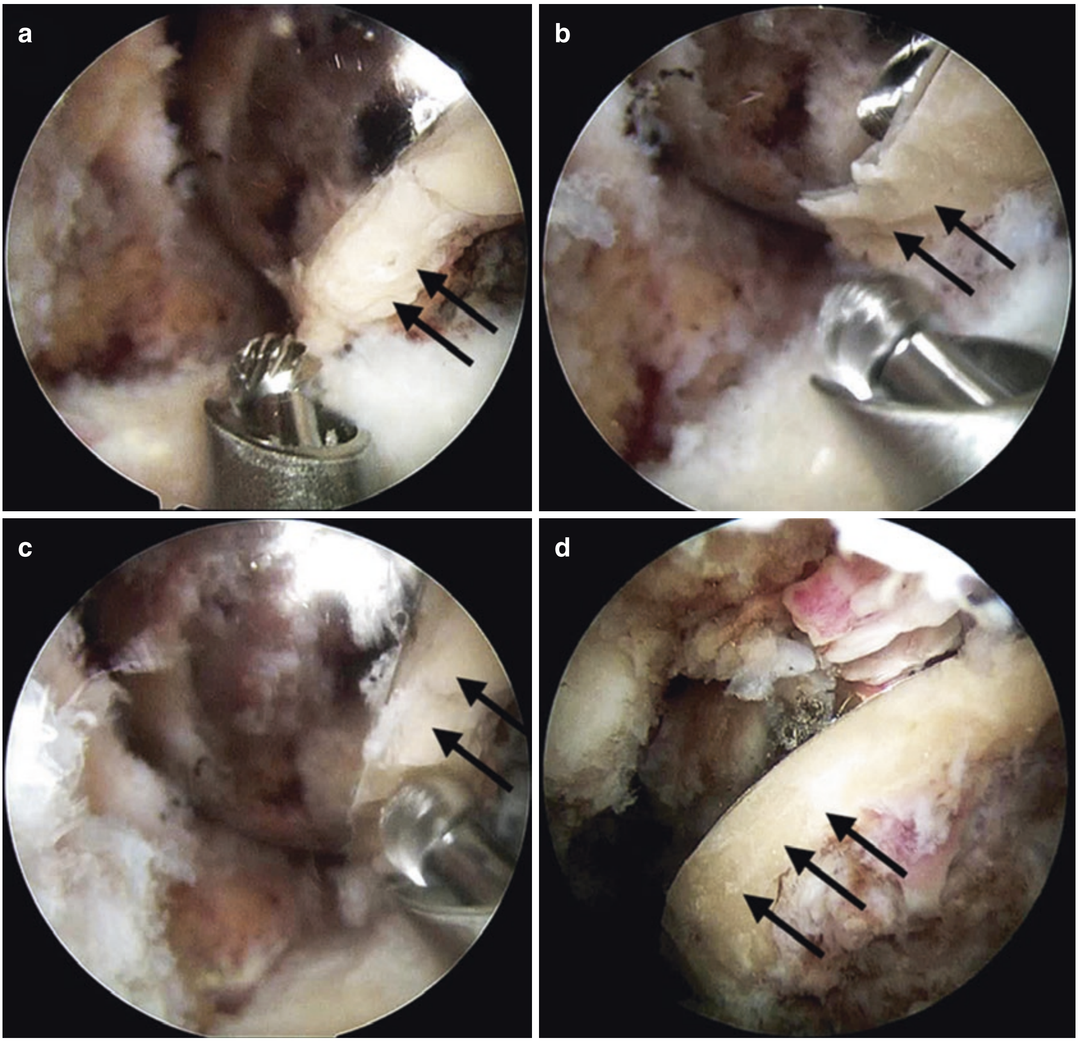

Fig. 2.6 (**a**) Bone bump at the head–neck junction (arrows). (**b**, **c**) Progressive bone resection to restore anterior neck offset. (**d**) Final check of free range of motion

be successful in performing iliopsoas tendon tenotomy, debridement of soft tissue, and resection of the bone impingement area (Fig. 2.7). In contrast, patients without a clear cause of pain offer no benefit and can even exacerbate symptoms [36].

A retrospective study evaluated 15 patients who had incapacitating groin pain following resurfacing arthroplasty. Among five patients with suspected iliopsoas impingement, release was done in four of them. In three patients with suspected impingement, anterior bone resection was done. In seven patients, arthroscopic biopsy was done. Two patients had metal wear on histology and two others had specific cell markers positive for metal allergy. Authors recommended multiple samples to be taken for histological examination and culture when hip arthroscopy is performed in painful hip resurfacing [35].

Evaluation of component loosening in painful hip resurfacing was also described. They concluded that hip arthroscopy allows good visualization of the component surfaces and enables the surgeon to assess component loosening [37]. In a case report, it was described a surgical technique of arthroscopic capsular plication in a case of subluxation after resurfacing arthroplasty with successful outcome

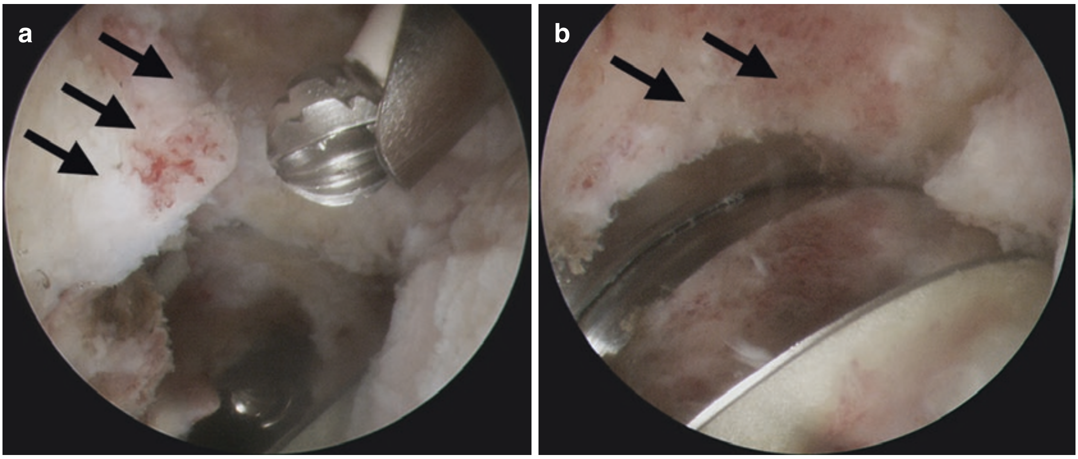

Fig. 2.7 (**a**) Bone prominence at the acetabular rim (arrows). (**b**) Bone resection (arrows) with a round 5 mm burr

[15]. The largest series of hip arthroscopy in painful hip resurfacing included 68 patients. First group of 41 patients had a diagnosis (17 iliopsoas tendinopathy, 17 metal debris synovial reaction, and 7 anterior hip impingement). In a second group of 27 patients, preoperative workup had failed to establish a conclusive diagnosis. Among the first group, 93% had improvement in WOMAC—Western Ontario and McMaster Universities Osteoarthritis Index—scores. Conversion rate to THA were 7% in first group and 37% in the second group. The authors concluded that arthroscopy after hip resurfacing is generally safe and allows good visualization of component surfaces, synovium, and surrounding tissues, with the advantage of dynamic joint and component evaluation. Complication rate after hip arthroscopy in painful hip resurfacing might reach 7%. Heterotopic ossification, nerve damage, and infection have been reported as main complications [36].

Tips and Tricks

- Dynamic evaluation could detect a bone prominence at the femoral neck that create an impingement against acetabular component.
- Synovial biopsy samples should be taken to rule out metal hypersensitivity.
- Acetabular overcoverage is a risk factor for psoas irritation, with a redness area along iliopsoas tendon at this level.

2.9 Iliopsoas Impingement

2.9.1 Introduction

Iliopsoas impingement after total hip replacement is a potential cause of persistent pain with an estimated frequency of 4.4% [38]. Postel initially described this condition in 1975 [39] and posteriorly Lasquene in 1991 [40].

There are various etiologies postulated, which can be classified as [41, 42]:

1. Anatomic: Morphological variations may leave anterior cup undercoverage as well as deficient anterior wall (developmental dysplasia of the hip [DDH]).
2. Surgical: Inadequate cup anteversion, overreaming anteriorly (deficient anterior wall), insufficient reaming (cup lateralization) [43].
3. Implant related: Long protruding screws inside iliopsoas, oversized cup, bulky femoral collar that overhangs the calcar, extrusion of intrapelvic cement, large diameter head, or resurfacing implant [44–48].

Different reports in literature show that the incidence of this iliopsoas impingement after hip resurfacing arthroplasty is more frequent than previously assumed. Because the femoral head–neck junction is preserved in this sort of implant, patients may be at greater risk of impingement, leading to abnormal wear patterns and pain [49].

2.9.2 Diagnosis

Diagnosis can be made mainly through history, physical examination, and radiographs. Most patients develop symptoms typically few months after THA surgery. The main presenting complaint is pain in the groin exacerbated by activities such as rising from a chair, getting in and out of a car, climbing stairs, going into and out of the bed, or standing up from a sitting position from a chair [50]. The patient may typically use both his hands to lift his thigh while lying on the examination table. Rarely, patients describe a snapping sensation.

On physical examination, the most common finding is groin pain with resisted hip flexion (particularly, resisted straight-leg raising) and with iliopsoas stretching [51]. The pain can also be elicited by passive hyperextension, as well as active external rotation, and extension of the hip joint [52]. Patients have tenderness on palpation in the area of the groin, and, rarely, a snapping of the tendon can be palpated, or a bursa can be felt [53].

Radiographs can suggest risk factors for impingement like insufficient cup anteversion, impinging screws, or femoral collar. Computed tomography (CT) may be useful to demonstrate the acetabular component prominence at the anteroinferior acetabular rim due to less anteversion. CT gives the best estimation of acetabular component version, and anterior overhang can also be quantified. It was demonstrated that an acetabular overhang of more than 12 mm was associated with an iliopsoas impingement or bursa hypertrophy while less than 8 mm was not associated with clinical symptoms [54]. Ultrasonography and magnetic resonance imaging can be used to assess iliopsoas tendinopathy. Ultrasound (US) evaluation shows that the iliopsoas tendon lies more ventral and medial to the acetabular component. US directly visualizes the presence of tendonitis or fluid effusion at iliopsoas bursa. It can also demonstrate impingement during active movements (dynamic US). Ultrasound was proposed as the first line investigation tool because it is a noninvasive, inexpensive, readily available technique that can be performed under dynamic conditions and also guide infiltration of local anesthetic or steroid [55].

The differential diagnosis clarification can be difficult. Persistent complaints after hip replacement can be acquired through a low-grade infection, an acetabular or femoral loosening, and occult fracture in the pelvis or the acetabulum. Occasionally, these complaints can be originated from the sacroiliac joint or the lumbar vertebrae. Rarely, these complaints can be caused by intra-abdominal, retroperitoneal, and vascular problems. The most important diagnostic test is the local anesthesia test. X-ray image guided injection of 2 mL anesthesia is injected into the area of the iliopsoas tendon sheath, and the patient reports how his complaints changed within the next minutes [43, 44, 56–58].

2.9.3 Conservative Treatment

Nonoperative treatment includes physiotherapy, nonsteroidal anti-inflammatory drugs (NSAIDs), and corticosteroid injections into the iliopsoas tendon sheath [43]. Nonoperative treatment leads to resolution of symptoms in up to 50% of cases [38]. Infiltration was recommended in the literature as the first therapeutic step [59]. It should be guided under ultrasound, CT, or fluoroscopic support and has been demonstrated useful as a diagnostic and therapeutic tool [56, 60, 61]. Other studies have suggested only a diagnostic role of such injections in case of marked pain relief that lasts several weeks [38, 41–43]. Fluoroscopically guided injection of botulinum toxin in iliopsoas has been also reported with good pain relief at 6 months of follow-up [62].

2.9.4 Surgical Treatment

Although, surgical treatment is a common option in patients with nonoperative treatment failure, only a few studies compare these two options. In a cohort of 49 patients, outcomes of operative versus nonoperative treatment were evaluated. Patients were treated with acetabular revision (21 cases), open iliopsoas tenotomy (8 cases), and nonoperative management with injections (20 cases). Nonoperative management led to groin pain resolution in only 50% of patients compared to 76% in operative group [38].

Dora et al. [43] reviewed 30 hips with iliopsoas impingement. All had a previous conservative treatment that failed. At final follow-up, operative treatment resulted in 81.8% favorable outcome. Same results were obtained in a recent study where surgical treatment solved groin pain in up to 76% of patients [38].

When surgical treatment is applied, it includes the release of the iliopsoas tendon alone or the removal of cement and prominent screws, and the revision of the iliopsoas muscle alone or in combination with iliopsoas tenotomy [54, 63, 64].

Classically, surgical treatment of psoas tendinopathy can be performed through open or arthroscopic tenotomy [60].

2.9.4.1 Open Surgery

In some cases, it may be necessary to revise the acetabular component [65]. Amount of acetabular component prominence in hip profile radiograph should be measured. Prominence less than 8 mm can be treated with tenotomy. In cases with prominence greater than or equal to 8 mm, acetabular revision with or without iliopsoas tenotomy should be considered. Patients treated surgically based on this algorithm obtained improvement in their symptoms in 94% of cases [38]. Regarding the approach, some authors proposed a posterior approach to tendon [50], but other authors described anterior or anterolateral approaches [43]. O'Sullivan used previous arthroplasty incision to explore and release iliopsoas at lesser trochanter combined with excision of lesser trochanter [53].

2.9.4.2 Arthroscopic Technique

Hip arthroscopy can represent gold standard in anterior iliopsoas impingement treatment after THA. Arthroscopic technique appears to be particularly appealing and advantageous, because it minimally involves the patient's morbidity. Although different methods have been described for the arthroscopic release, mainly two techniques have been proposed for iliopsoas arthroscopic tenotomy.

1. Tenotomy at the level of the lesser trochanter releases the most distal portion of the iliopsoas [60, 66]. With the patient in supine position, the hip is externally rotated and release performed extra-articular at lesser trochanter. With this approach, grade 5 muscle power was recovered in mean 3.25 months. Patel et al. suggested that extra-articular technique provides more complete release as there is higher proportion of tendon to muscle (60% tendon, 40% muscle) compared to central compartment (40% tendon, 60% muscle) [67]. Also, since it does not violate the hip joint, chances of infection and iatrogenic instability are less. Williams et al. [68] reported 13 patients undergoing extra-articular tenotomy. Subjective flexion weakness of 20% was observed at 12 weeks post procedure. Majority of patients (62%) reported complete relief. As a technique modification, they suggested removing the distal stump of the tendon after sectioning to avoid recurrence.
2. Other option is arthroscopic transcapsular tenotomy performed according to the original Wettstein technique [69]. The arthroscopic approach through the capsule allows direct tendon release at the level of acetabular component with conserved strength of flexion for all patients in the series [61, 69, 70]. Patient is positioned in a supine position with slight traction to obtain 0.5 cm distraction and leg flexed 30° to relax anterior capsule [20] (Fig. 2.8).

In a recent work on arthroscopic iliopsoas tenotomy after total hip replacement, 80% of patients included in the work showed complete relief after a mean of follow-up period of 20 months [60]. This result is considered better than revision arthroplasty as well as open tenotomy. A prospective multicenter study evaluated outcomes of 64 iliopsoas, arthroscopic tenotomies, with a median follow-up of 8 months. At last follow-up, 92% of the patients presented

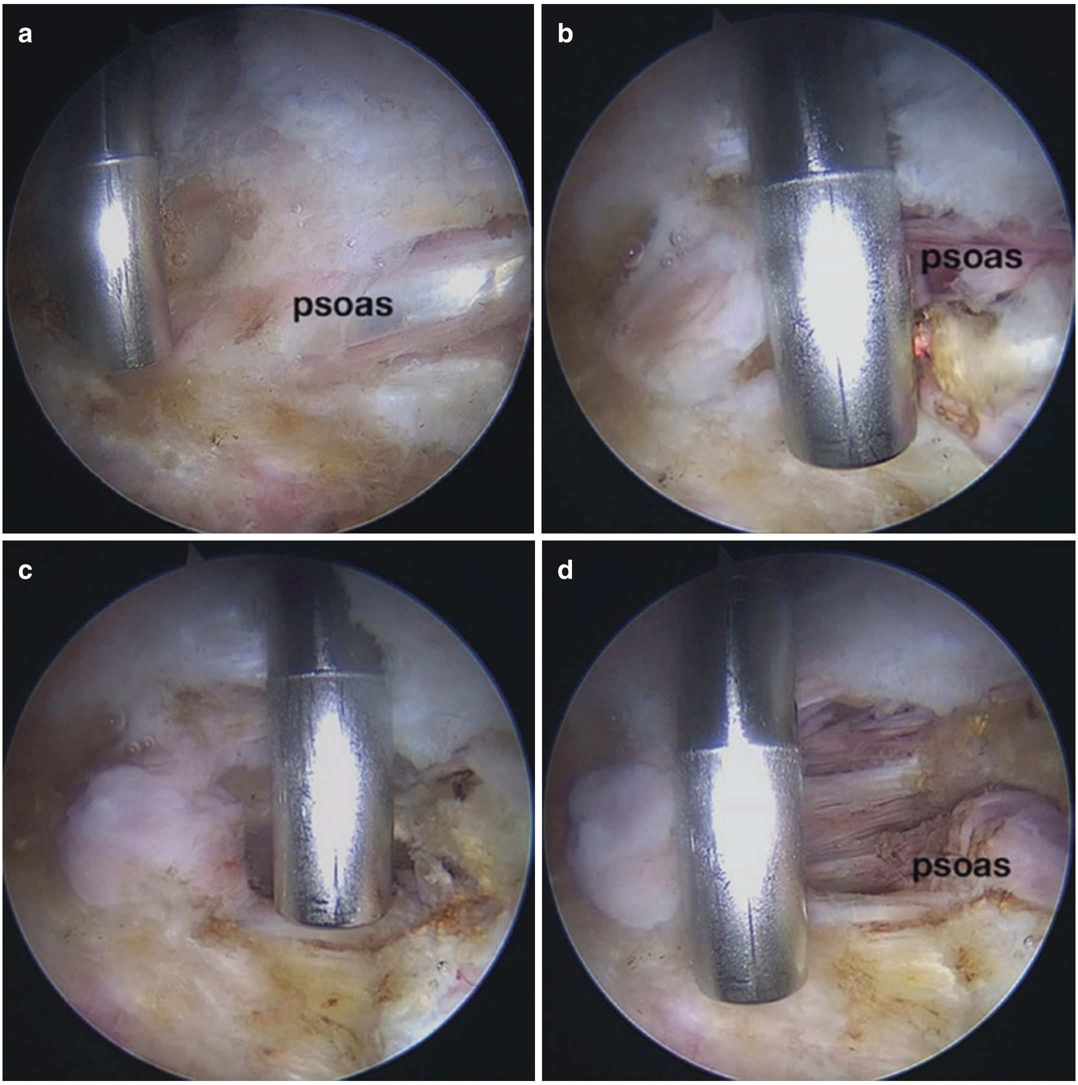

Fig. 2.8 (**a**) View of psoas tendon after capsular opening (transcapsular approach). (**b**, **c**) Proximal psoas tenotomy. (**d**) Complete release of tendon portion (40% of complete iliopsoas thickness)

with pain improvement. In two cases, arthroscopy indicated metallosis and acetabular component was revised. Complications occurred in two cases (3.2%), with a THA dislocation (transcapsular tenotomy), and one compressive hematoma affecting the peroneal nerve resolved quickly with surgical drainage [41]. Recently, iliopsoas tenotomy at the level of the acetabular component was proposed as a safe alternative. In a cohort of 13 patients, with this technique all patients presented significant improvement in pain and function after an average follow-up of 10 months. No complications were observed [71]. In summary, arthroscopic iliopsoas release guarantees fewer complications than standard open technique but it has limits related to long learning curve. Arthroscopic approaches at lesser trochanter level, or transcapsular, offer same short-term clinical results [72].

O'Connell et al. [73] conducted a systematic review of literature comparing outcomes following arthroscopic and open iliopsoas release. Overall, 7 studies with total 88 patients (61 treated arthroscopically and 27 treated with open tenotomy) were reviewed. They reported fewer complications and higher success rate in the arthroscopy group. They found that tenotomy did not decrease hip flexion strength. They also suggested that tenotomy can resolve symptoms even in case of mechanical impingement and should be considered prior to revision, considering the increased risk of complications with revision. These findings complemented those by Dora et al. [43] who concluded that symptom resolution was similar or even better for tenotomy group as compared to revision group.

Tips and Tricks

- CT is recommended to investigate acetabular component anteversion and screw protrusion as a cause of psoas irritation.
- First step in treatment should be psoas infiltration that could also be used as diagnostic confirmation.
- When conservative treatment fails, arthroscopic iliopsoas release at the acetabular level using a transcapsular technique is a good option with low complication rate and acceptable clinical results.

2.10 Conclusion

Hip arthroscopy has been well established in managing iliopsoas impingement in painful THA and as a diagnostic tool for unexplained pain following a seemingly normal THA. Main published indications of hip arthroscopy in painful THA in the literature are iliopsoas impingement, reactive synovitis, adhesions, loose bodies, and infection. Hip arthroscopy in treatment of anterior iliopsoas impingement is the most useful instrument, being less invasive than classic open technique. With the ever-expanding portfolio of indications, hip arthroscopy in THA is going to undergo a steep rise in numbers and hence, more associated complications will appear. The technical challenge with regard to hip arthroscopy in the setting of hip arthroplasty and associated learning curve must be addressed.

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Part II

Bony Deformities

Femoral Osteochondroplasty

3

M. A. Sadakah and Michael Dienst

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 intra-articular 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-

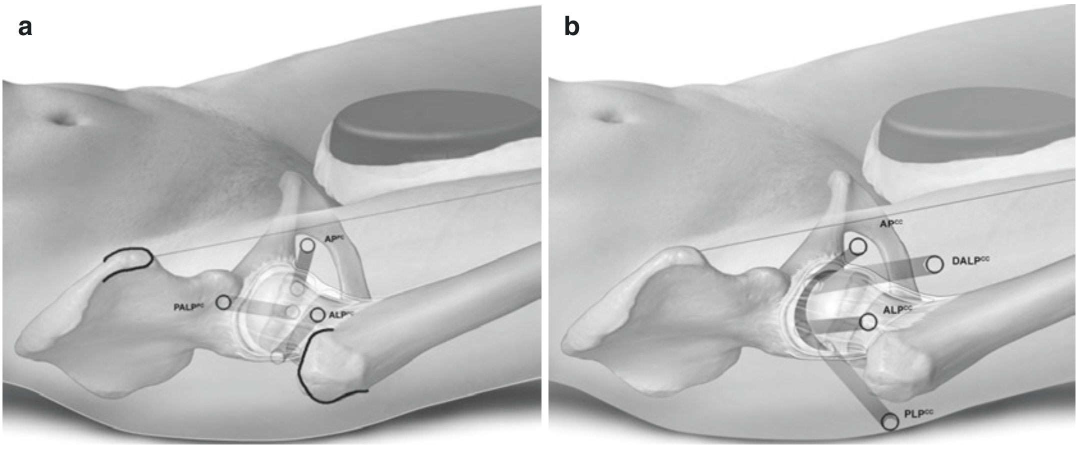

Fig. 3.1 (**a**, **b**) Portals to the PC (**a**) and CC (**b**). Courtesy of Michael Dienst, MD

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).

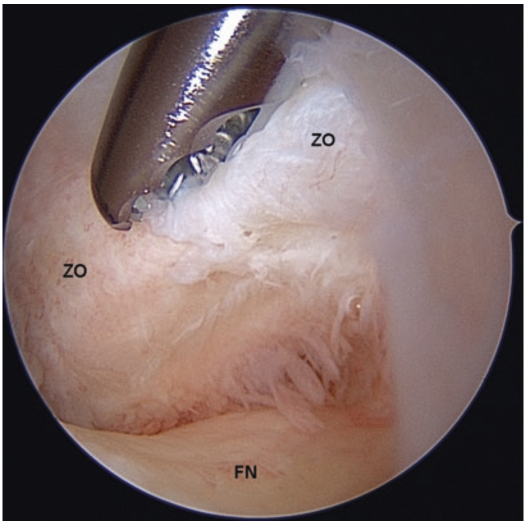

Fig. 3.2 Release/internal thinning of the Zona orbicularis (ZO). View from the $PALP^{PC}$, Shaver via AP^{PC}. *FN* femoral neck. Courtesy of Michael Dienst, MD

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.

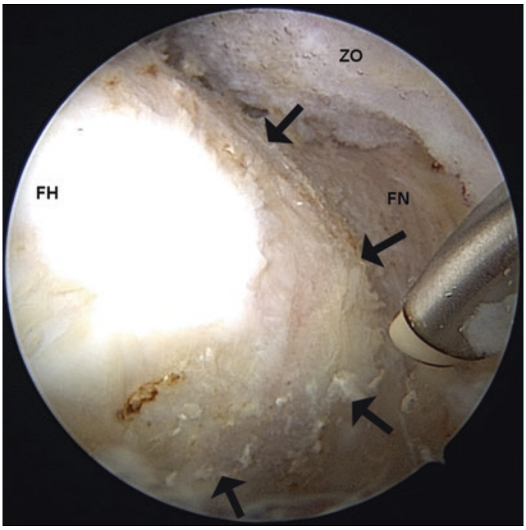

Fig. 3.3 Assessment of the extent of the Cam deformity (arrows). View from the PALP^{PC}. *FN* femoral neck, *FH* femoral head, *ZO* Zona orbicularis. Courtesy of Michael Dienst, MD

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-

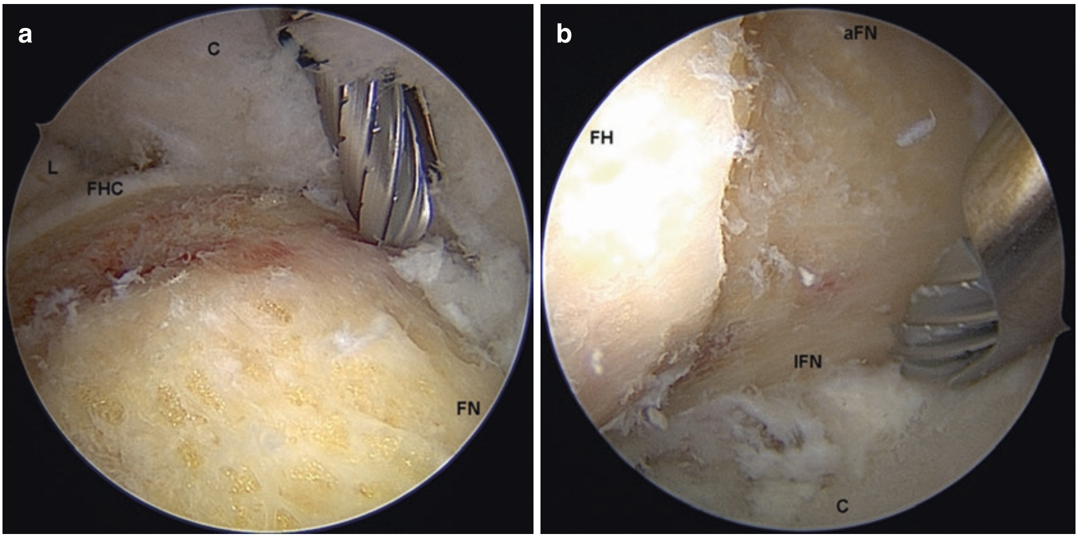

Fig. 3.4 (**a**, **b**) Resection of the anterior (**a**) and anterolateral (**b**) extent of the Cam deformity. View from the PALP^{PC}, burr via AP^{PC}. *C* capsule, *FN* femoral neck, *aFN* anterior femoral neck, *lFN* lateral femoral neck, *L* acetabular labrum, *FH* femoral head, *FHC* femoral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

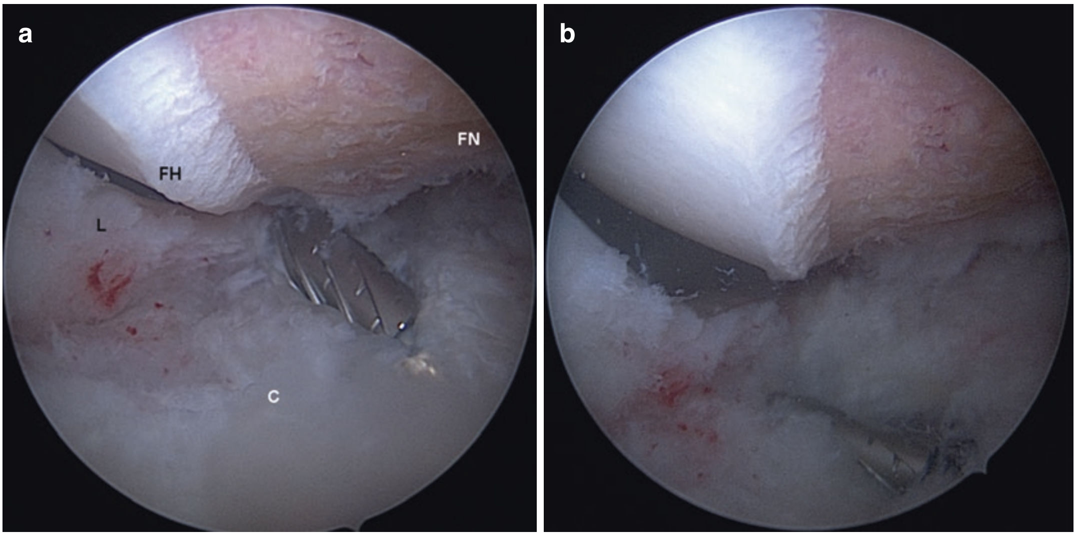

Fig. 3.5 (**a**, **b**) Lateral extent of the Cam deformity before (**a**) and after (**b**) resection. View from the PALP^{PC}, burr via ALP^{PC}. *C* capsule, *FN* femoral neck, *aFN* anterior femoral neck, *LFN* lateral femoral neck, *L* acetabular labrum, *FH* femoral head. Courtesy of Michael Dienst,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

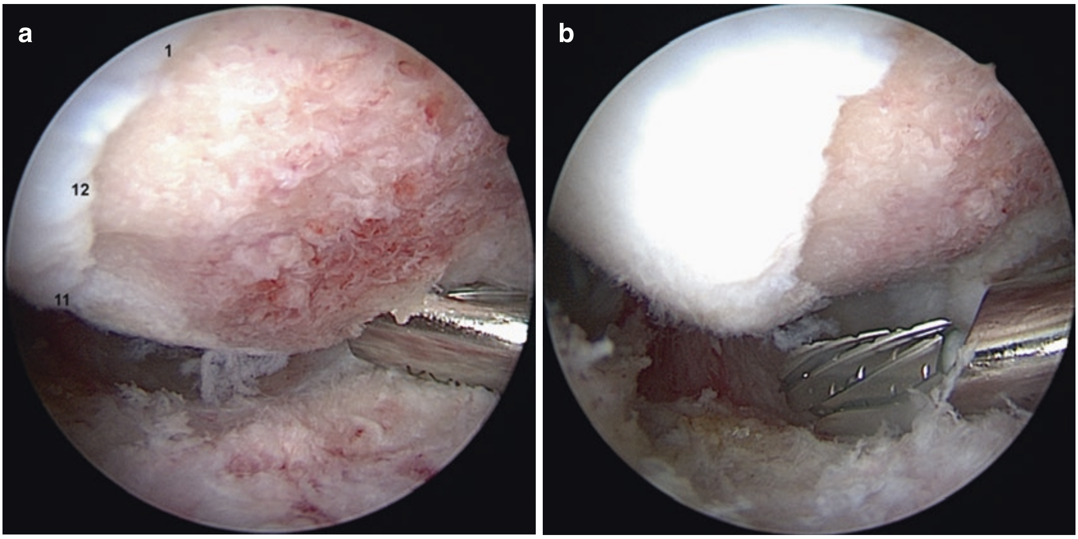

Fig. 3.6 (**a**, **b**) Resection of the lateral/posterolateral extent of the Cam deformity from the central compartment. View from the AP^{CC}, burr via ALP^{PC} before (**a**) and after (**b**) resection. Courtesy of Michael Dienst, MD

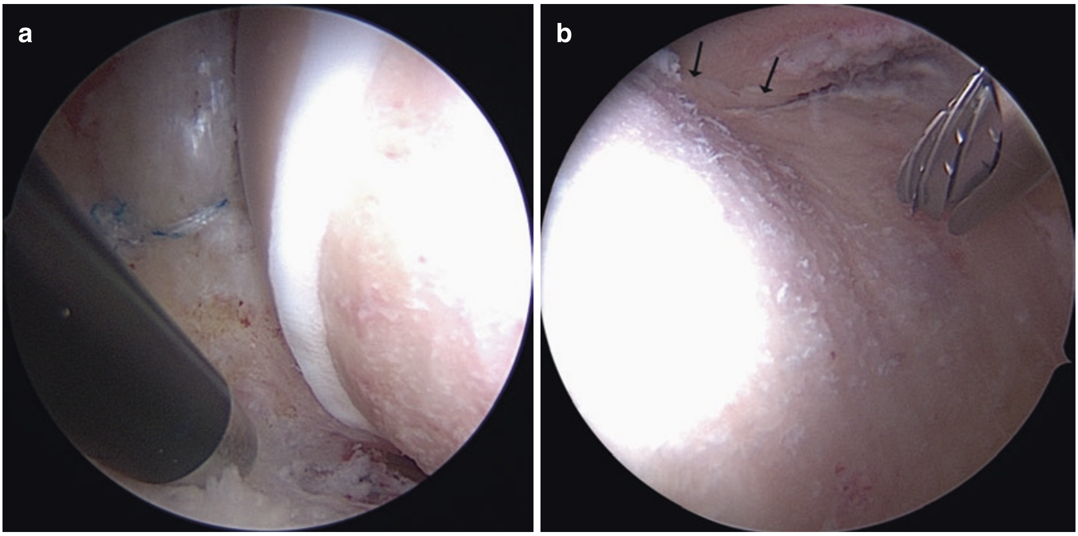

Fig. 3.7 (**a**–**c**) Final arthroscopic viewing of an adequate Cam resection. Lateral head area with the relation of the lateral to the repaired labrum (**a**), anterior head–neck junction (**b**) with a precise transition of a concave–convex shape with view medially to the medial synovial fold (arrows) 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

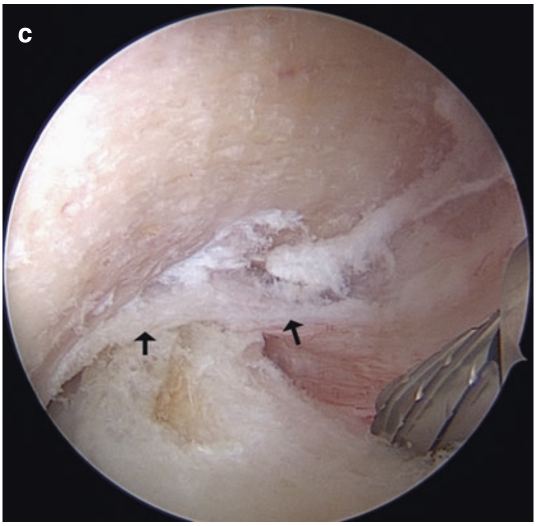

Fig. 3.7 (continued)

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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Acetabular Rim Trimming

4

Matti Seppänen

4.1 Introduction

In pincer femoroacetabular impingement (FAI) hip motion is limited due to functionally excessive acetabulum. Acetabulum may be too deep; there may be a regional "bumper" on the rim or it may be maloriented (retroversion of the acetabulum). Pincer situation may be caused also by large os acetabuli. Excessive anterior rim of the acetabulum may cause contact between rim and femoral head-neck junction and lift off of the femoral head from the acetabulum. This lift off may cause posterior "contrecoup" chondral damage to the posterior acetabular cartilage [1].

4.2 Preoperative Planning

When deciding the operative strategy for symptomatic pincer dominating FAI surgery, special attention should be paid for the acetabular version and anterior to posterior acetabular coverage. If standing pelvic X-ray shows positive posterior wall sign and/or positive ischial spine sign, 3D imaging should be done (3D CT of preferable 3D kinematic MRI) with calculation of total, anterior and posterior acetabular coverage. If the posterior coverage is diminished, problem is retroversion of the acetabulum, not over-coverage of the anterior wall, and right operative treatment is correction of the acetabular anteversion with rotational periacetabular osteotomy (RPAO). In these situations, anterior acetabular rim trimming will worsen anterior–posterior dysplasia.

If large os acetabuli is causing pincer situation, resection is often a good option for operative treatment. Before this decision special attention should be paid for acetabular coverage after resection. If os acetabuli is large, after resection acetabular coverage may diminish causing iatrogenic dysplasia situation. In this kind of situation simultaneous periacetabular osteotomy should be considered.

The most common reason for the rim trimming is combined FAI with limited bumper on the anterior and anterocranial acetabular rim and CAM bumper on the femoral head-neck border. The domination of these two varies, but in authors opinion both should be treated if operative treatment is chosen.

If pincer situation is due to coxa profunda or acetabular protrusion, you should be prepared for the labral reconstruction in same operation. As a rule of thumb, deeper the acetabulum, thinner the labrum and vice versa. After the labral detachment from the rim, you might end up with the

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situation where remaining labrum is only few millimeters thick.

4.3 Arthroscopic Treatment (Video 4.1)

On lateral decubitus position traction is applied and the lateral portal is done under fluoroscopic guidance. After entering inside the joint with 70°arthroscope, mid-anterior portal is done under visualization. Limited capsulotomy (approximately 1 cm) is done with knife or with the electrocautery probe. Labral detachment is started from the anterior part of the acetabulum with electrocautery from the lateral side of the labrum. If chondrolabral junction is intact, it should not be perforated while detaching the labrum. Special attention is paid for the cranial labrum where the synovia comes lid of the labrum and the lateral sulcus is almost nonexistent [2]. After anterior detachment camera's poral is switch to the mid-anterior portal and detachment can be continued towards the posterior direction, by the antero lateral portal [3]. If possible, posterior rim trimming is avoided due to the thin bony wall of the posterior bony wall of the acetabulum. Due to that, suturing the labrum might be difficult.

After detaching the desired part of the labrum and evaluating the pincer area, the rim resection begins from its lower anterior part with a 4.5 or 5 mm burr blade. Width of the burr blade is used also to measure the amount of resection.

Resection is continued to the cranial direction and special attention is paid not to resect too much in the beginning. It is easier to resect a little and try to create flat rim first, then deepen the resection to achieve preoperatively planned form of acetabular wall. During the procedure, fluoroscopy is used to ensure right place and deepness of resection. When using the fluoroscopic visualization, you must remember that image of the acetabulum is very sensitive for the positioning of the pelvis and angle of the c-arm, so preoperative planning should be kept in mind. The biggest risk in this phase is over-resection of anterior or cranial rim and creation of anterior undercoverage. For the cranial part of rim resection, arthroscope is changed to the mid-anterior portal and detachment of the labrum and resection of the cranial acetabular rim are continued from the lateral portal.

Because the cranial capsule is thin and attachment is very close to the labrum, muscle fibers are often exposed. To avoid muscle fibers to limit the visualization, it is reasonable to use as low fluid pressure as possible (with fluid pump used by author 35–40 mmHg). This also limits the risk of intra-abdominal extravasation.

When the preoperatively planned lateral center-edge (LCE) angle is achieved, it's time for labral saturation. Favorable LCE angle is between 35 and 30°. Going under 30° raises the risk of local under coverage. Because the goal for rim trimming is close to the highest normal LCE angle, the Tönnis angle is low, and the direction of the lateral acetabular joint surface is very horizontal, extra caution should be paid for the angle of the drill bit when drilling the anchor holes. Because the posterior wall of the acetabulum is thin, authors preference is to use all suture anchors. Joint surface perforation should be avoided. Anchors are placed approximately 1 cm to each other and sutures are not over-tightened.

Because the labrum is originally thin, mattress sutures are not possible without damaging labrum. Loop like sutures are favorable also because labral detachment is usually wide and piercing the labrum is difficult.

After labral reinsertion, traction is released and arthroscope is slided to the peripheral compartment to evaluate the shape of femoral head-neck junction and need of femoral osteochondroplasty.

Traction time should not exceed 60 min. If intra-articular work is not over after 60 minutes, traction is released for at least 15 min. During that time peripheral compartment can be evaluated and if necessary, femoral osteochondroplasty is done. After peripheral compartment work, traction is reapplied and labral suture is completed.

If adequate distraction is not possible to achieve with moderate distraction force, it is better to change the strategy and start from the peripheral compartment. Rim trimming is then performed without distraction, taking special attention not to damage the cartilage of the femoral head by flexing the hip. Once rim resection done, the traction can be applied allowing labrum sutures.

Tips

- CE-angle over 35° pincer is possible
  - Aim to CE 30°–35°, avoid over-resection
- Posterior wall line goes medial to the center of femoral head and ischial spine is visible in pelvic X-ray
  - Be aware of acetabular retroversion and continue with 3D imaging
  - If posterior coverage is diminished, consider RPAO
- In global pincer labrum is often small and thin: be prepared for labral reconstruction or augmentation in same operation
- Resection of the large os acetabuli may lead to iatrogenic dysplasia of the acetabulum
- Bony anatomy correction is the key to the success of the operative treatment

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5

Open Femoral Osteochondroplasty and Rim Trimming

Alessandro Aprato, Matteo Olivero,
Alessandro Massè, and Reinhold Ganz

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].

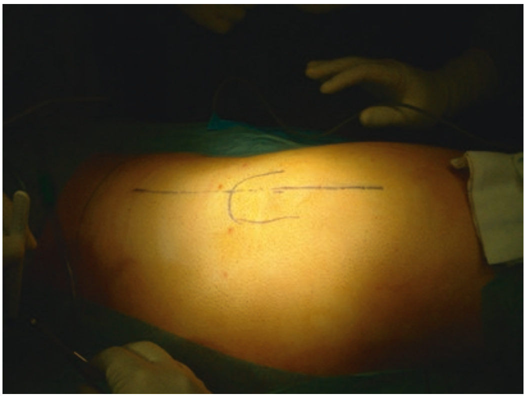

Fig. 5.2 The straight incision for Gibson's approach. It is less invasive than the Kocher-Langenbeck approach and usually provides an aesthetically better result of the contour of the thigh

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

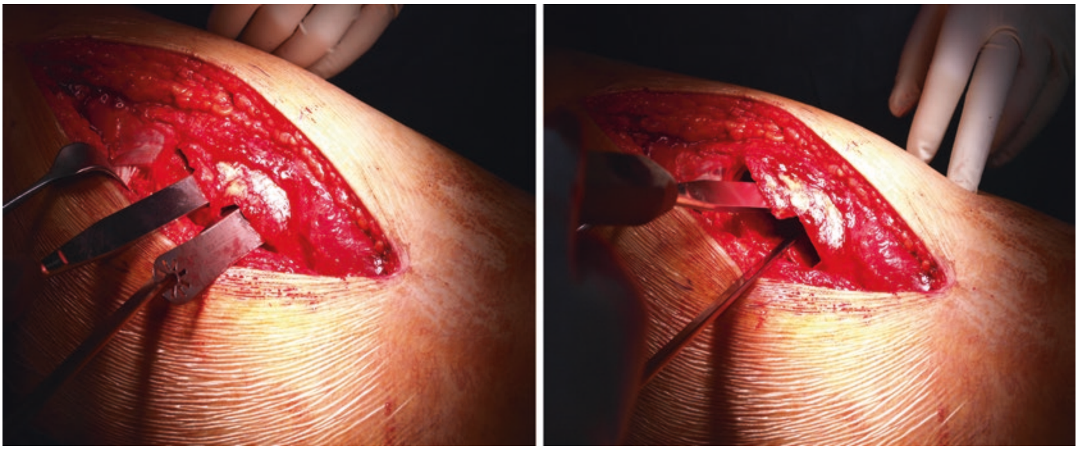

Fig. 5.4 "Z" osteotomy of the greater trochanter

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

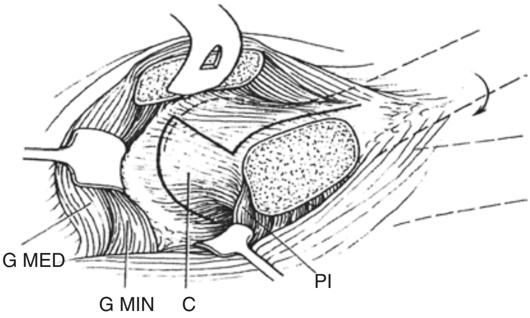

Fig. 5.5 Z-capsulotomy. The first incision runs anterolaterally along femoral neck; proximally it is extended posteriorly parallel to the acetabular rim; and distally it is extended anteriorly towards the lesser trochanter

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.

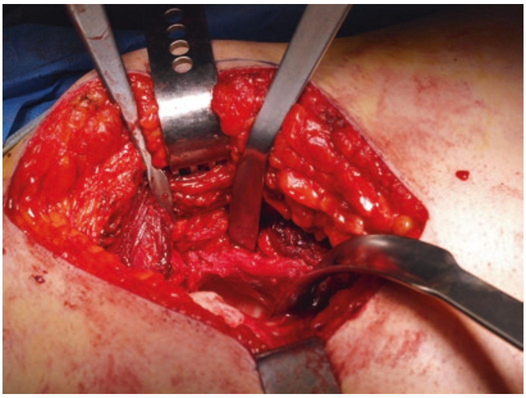

Fig. 5.6 Position of the retractors for acetabular exposure. One retractor at the 12 o'clock, one retractor anteriorly at the acetabular rim and a large, narrow, curved Hohmann retractor posteriorly to the acetabular rim and against the femoral neck

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].

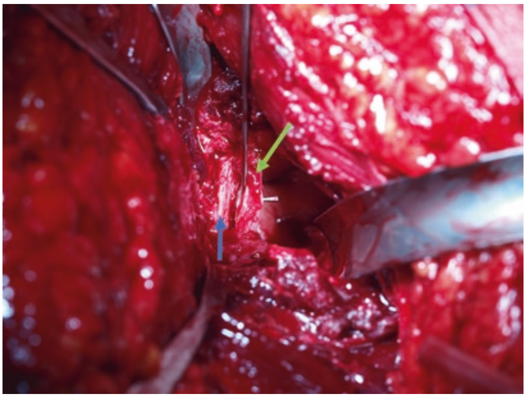

Fig. 5.7 Labrum detached from the acetabular rim by sharp dissection. Evaluation of the labrum with a small probe. *Green arrow*: detached labrum. *Blue arrow*: acetabular rim

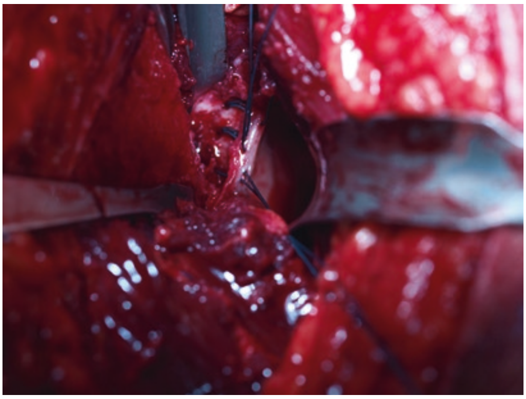

Fig. 5.8 Sutures are passed through the labral substance. The definitive suture tightening will be performed only after hip reduction to obtain a more anatomic alignment of the labrum and a perfect knots tension

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).

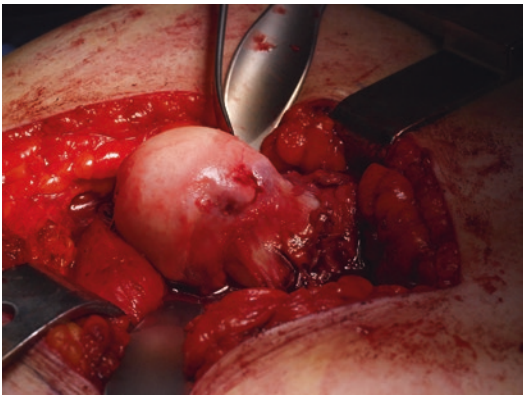
Fig. 5.9 Position of retractors for exposure of the femoral head and neck. The femoral head is further elevated with two blunt Hohmann retractors, placed around the neck

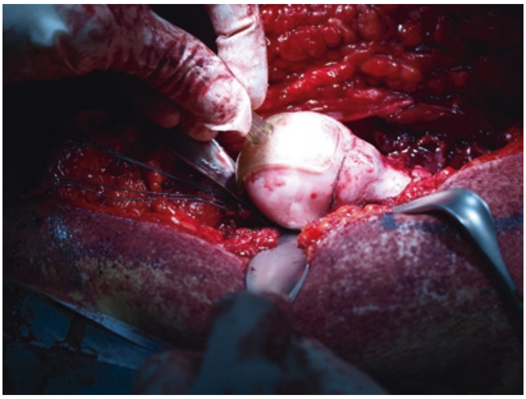
Fig. 5.10 Identification and evaluation of the femoral bump with sized transparent plastic template

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

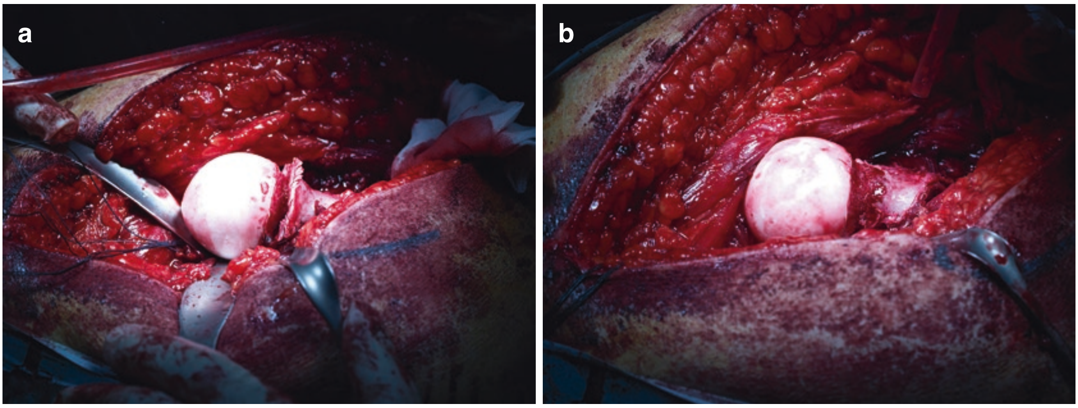

Fig. 5.11 (**a**) Osteochondroplasty of head–neck femoral junction. (**b**) Head–neck junction after the osteochondroplasty

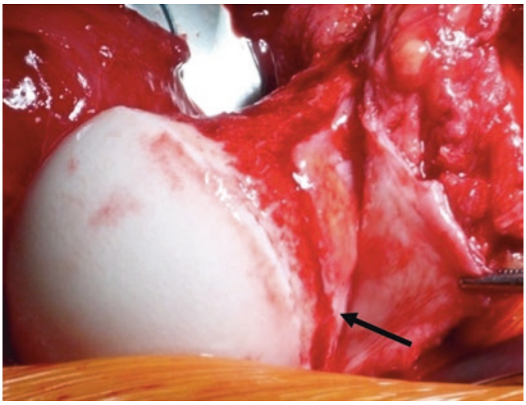

Fig. 5.12 Limited bone resection proximal to the retinacular flap. *Black arrow*: Posterosuperior periosteal flap

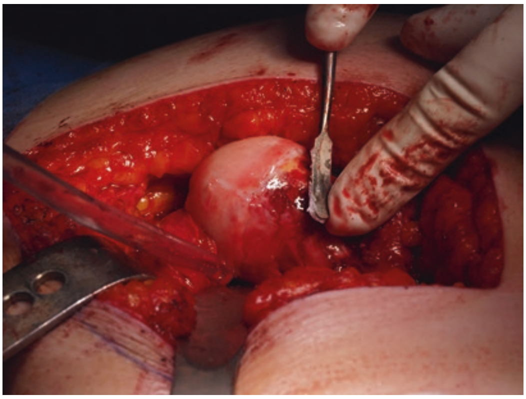

Fig. 5.13 Application of bone wax on the debrided bone surface

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.

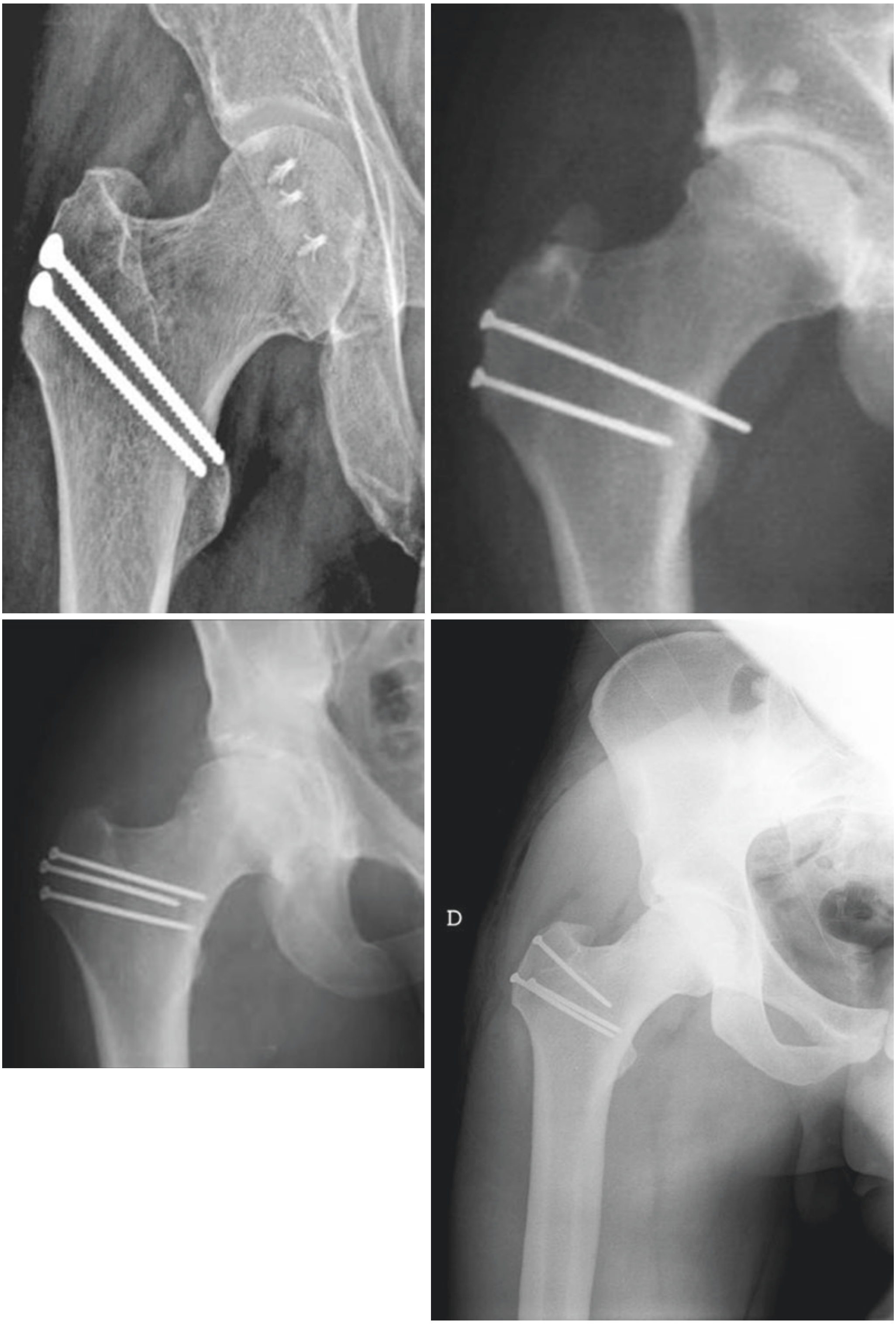

Fig. 5.14 Postoperative X-rays. Fixation of the trochanter with 3.5-mm screws

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Subspine Impingement Decompression

6

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and Richard Villar

6.1 Introduction

Subspine impingement is an extra-articular form of impingement around the hip joint. The word 'impinge' is a verb defined in *Cambridge Dictionary* as 'to have an effect on something, often causing problems by limiting it in some way'. Femoroacetabular impingement (FAI) as a cause of hip pain was brought to academic attention by Ganz et al. [1]. Traditionally, two forms of FAI are described, namely Cam and Pincer [1, 2]. However, over the last 20 years not only extra-articular impingement variants have been identified but also their concomitant presence has been recognised. Various forms of impingement phenomena around the hip joint are recognised now including Cam, Pincer (focal and global), mixed, ischiofemoral and subspine in broad terms [1, 3–5]. Subspine impingement refers to a conflict of a bony prominence that exists between the anterior inferior iliac spine (AIIS) and acetabular rim with that of femoral neck in extreme flexion. This may or may not coexist with an underlying prominent acetabular rim (Pincer) or an abnormal AIIS (true AIIS impingement) or soft tissue damage including both intra- and extra-capsular structures. We have to understand the anatomy to appreciate these subtle differences. Treatment ranges from non-operative management to open surgery or arthroscopic intervention.

6.1.1 Anatomical Considerations

Anterior inferior iliac spine gives origin to direct head of rectus femoris and iliocapsularis. It is anteromedial to most lateral part of the acetabulum. The mean length of AIIS apophysis is 31.5 mm (range, 23–39.5 mm) and a mean width of 11.9 mm [6, 7]. The AIIS prominence projects outwards a mean 6.4 mm (range, 3.5–10 mm), which is described as the height. Clearly, an anomaly of height, width and length can precipitate an impingement phenomenon. However, perhaps the most important factor is the distance from the acetabular rim to base of the AIIS and the shape in that region. In most people, the bony rim underneath the AIIS is a smooth curve (concave) that provides attachment to iliofemoral ligament and part of hip joint capsule and the mean distance from the base of the AIIS to the acetabular rim is 21.8 mm (range, 10.4–32.3 mm) [6–9]. However, this shape and distance can be compromised in certain individuals and can precipitate subspine impingement. Anatomically, AIIS has two facets: (a) The superior facet, which provides attachment to direct head of rectus femoris, and

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(b) the inferior facet, which is the attachment for iliocapsularis [9].

There are three variants of the AIIS morphology described [10]. These were based on three-dimensional (3D) computed tomographic (CT) interpretations of 53 patients with femoroacetabular impingement. The variants of AIIS are described as Type 1 if there a smooth line of ilium between most inferior aspects of AIIS and acetabulum, as Type 2 if AIIS projects to level or just above anterosuperior acetabular rim and as Type 3 if AIIS projects distal to acetabular rim. This simple description does not take into account soft tissue component in this type of impingement phenomenon.

Subspine morphology was described after arthroscopic assessment and classified by Brian Kelly et al. into three variants [11]. Type 1 was considered normal and referred to a concave or flat surface caudal to AIIS and to the rim of the acetabulum. Type 2 referred to a bulging hypertrophy in the subspine region with a convex osseous projection reaching the acetabular rim but not beyond it. In Type 3, the prominence from subspine region projected anteroinferior to the acetabular rim but was distinctly separate from the acetabular rim.

6.2 Clinical Presentation

Typically, the patients presenting with subspine impingement are sporty individuals who present with activity-related discomfort in groin. Often these individuals engage in activities that increase stress on iliofemoral ligament and iliocapsularis including recurrent extension such as running or rotation of the hip like that experienced in sports with a change of direction [8, 12]. A subset of the patients reported a traumatic episode often several years ago where an injury to ‘hip flexors’ is reported. This may represent an old rectus femoris injury and the telltale signs of old injury may be present radiologically [9]. In vast majority of patients there is an insidious onset, which starts as groin pain in extreme activities but then leads to affect day-to-day function. They often report dull ache in the groin while seated in low chair. Groin pain, in particular, is accentuated with hyperflexion of the hip, adduction and internal rotation. Some of the symptoms may be related to associated soft tissue injuries, including those of intra-articular structures.

A thorough clinical assessment is suggested, including both general and specific clinical examination. A structured approach will include assessment of patients’ hypermobility status if suspected, biomechanical assessment in static and dynamic modes, gait assessment, foot and foot-ware assessment, functional squats, on the couch examination with thorough assessment of hip joint and comparison with the opposite side, including range of movement, strength and provocative tests. In addition, groin assessment must be carried out to rule out abdominal wall or groin disruptions that can mimic an impingement phenomenon.

6.3 Investigations

Investigations of the suspected subspine impingement include plain radiographs, anteroposterior (AP) view of the pelvis and lateral view of both hips for comparison. Plain radiographs are extremely helpful to evaluate AIIS morphology, acetabular rim morphology including any cross-over sign, identification of ischial spine sign and defining the anterior femoral head–neck junction morphology to evaluate for a cam lesion [3, 9, 13, 14]. Many times there is a mixed impingement picture. Authors always undertake magnetic resonance imaging (MRI) scan to evaluate intra-articular structures, femoral head vascularity and ruling out other pathologies such as stress fracture or tumours. CT scan and dynamic CT-assisted assessment are reserved for more complex cases and are helpful in pre-operative planning [3, 5]. In addition, haematological testing is reserved for patients suspected of underlying systemic problems and these include, in selected cases, HLA B27 assessment, full blood counts, erythrocyte sedimentation rate, C-Reactive Protein, autoantibody screen and vitamin D levels (Table 6.1).

Table 6.1 Investigations for suspected subspine impingement

All cases	Selected cases	Suspected systemic pathology
X-ray pelvis AP X-ray lateral both hips MRI hip and pelvis	CT scan CT dynamic assessment Diagnostic injection Dynamic USS	Full Blood Count test (FBC) CRP ESR Rheumatology screen Autoantibody screen HLA B-27

6.4 Treatment

Treatment options are discussed with patients. Non-operative treatment is worth considering while employing physical therapy, activity and training modification, biomechanics correction and a short course of non-steroidal anti-inflammatory drugs (NSAIDs). In refractory cases, surgical intervention is planned. Authors undertake exclusively arthroscopic intervention for subspine impingement; however, open surgical approaches are described. In most cases it is the arthroscopic approach; however, in certain types of AIIS morphology, it is combined with endoscopic approach to avoid excessive capsular damage.

Procedure is undertaken in lateral decubitus position under general anaesthesia with lumbar plexus block. A single shot of prophylactic antibiotics is used. The patient is placed in a well-padded dedicated distraction table. The central post is offset such that it sits on the ischium to avoid extra pressure on the perineum. After a trial of traction is checked under fluoroscopy, the traction is completely released. Patient is carefully prepped and draped. Posterolateral and anterolateral portals are used to access the hip joint. Posterolateral portal is initially used as the viewing portal. Anterolateral portal is used as the main working portal. However, as the subspine impingement decompression gets underway, the portals are reversed to complete the recession while avoiding excessive soft tissue disruption. Initially, a complete diagnostic round of the central compartment is undertaken before any procedures are performed. At 12:30 on the clock face, capsulotomy is extended. We do not routinely take down the labrum. At this stage, perilabral sulcus is developed with radiofrequency (RF) probe. Procedure is started with 90° RF probe, which is later substituted for 50° RF probe, depending on the access angle. Superior rim of the acetabulum is viewed. Reflected head of rectus is identified and preserved, while the bone caudal to AIIS is exposed. This is confirmed under fluoroscopy. Capsule is lifted up in a layer rather than excised to keep the ability for capsular repair at the end. Limited amount of iliofemoral ligament and iliocapsularis might have to be released at this stage. A 4.5-mm burr is used at 8000 revs/min to commence the excision. Pump pressure is kept between 35 and 50 mmHg to avoid excessive fluid extravasation. Arthroscopic recession is confirmed fluoroscopically. A planned depth of recession is carried out based on careful pre-operative planning. During the recession process superiorly, traction is reduced to keep traction time limited. Under arthroscopic and fluoroscopic control, any overhanging ossification is identified and recessed in a similar fashion. At this stage, if indicated and planned, acetabular rim recession is performed via retrolabral sulcus. In large pincer recessions only do we take down the labrum. A dynamic testing with hip flexion is performed at this stage to assess the depth of recession. Hip joint is distracted again and labrum repair as indicated is undertaken. Capsular repair is undertaken with suture anchors on the acetabular side. Intra-articular repair of chondral surfaces, if indicated, is completed at the end of the procedure.

In selected cases, where there is excessive anomalous shape of the AIIS with significant ‘hooking’ or calcification in the vicinity of rectus, an endoscopic approach can be employed. This involves extra-capsular approach directly to the bony prominence under fluoroscopic control using arthroscopy needles and Seldinger technique to develop the portals. Skin portals are same as used in posterolateral and anterolateral approach. Careful fluoroscopic control is used to avoid neurovascular damage. Once the bony prominence is visualised, it is cleared using RF probe and recession is carried out with 4.5-mm burr. Bone prominence responsible for AIIS impingement is recessed and dynamic testing is encouraged. This whole process is carried out without any traction.

Before finishing the procedure, access is made to peripheral compartment. To avoid further trauma to capsule, a separate peripheral compartment access is gained using superolateral portal with hip in 40° of flexion and 35° of abduction and knee gently flexed. This relaxes the anterior capsule. Once the viewing portal is established, the working portal access is gained directly from the anterolateral portal by reintroduction rather than undertaking capsulotomy. Full diagnostic round of the peripheral compartment is performed including dynamic assessment. Any associated Cam impingement lesion, if present, is addressed at this stage. Assessment of labral seal and capsular repair anterosuperior is also performed. Authors undertake peripheral compartment work without extensive capsulotomy, and capsular integrity, including zona orbicularis, is preserved in the peripheral compartment. Hip joint is instilled with hyaluronic acid at the completion of procedure.

As an illustration, we describe the case of a 26-year-old footballer who presented with insidious onset of groin and hip pain with interruptions to play. There was no distinct history of injury, but several ‘groin strains’ were reported. Clinical examination was consistent with femoroacetabular impingement. Patient has already failed multiple trials of non-operative physical therapy sessions at his local facility. Further assessment included biomechanical profile, plain radiographs, MRI scan and a CT assessment. He had a mixed impingement phenomenon with a Type 3 subspine impingement along with an abnormal AIIS morphology and a Cam lesion as shown in the 3-D CT model (Figs. 6.1 and 6.2). Arthroscopic treatment was discussed and carefully planned. Procedure was carried out in the usual format as described earlier. Access to hip joint was made planned using arthroscopic needles to avoid the over-hang of the subspine impingement lesion beyond the acetabular rim (Fig. 6.3). Posterosuperior viewing portal and anterosuperior working portals were developed. Intra-articular structures of the hip joint were carefully inspected before dealing with the

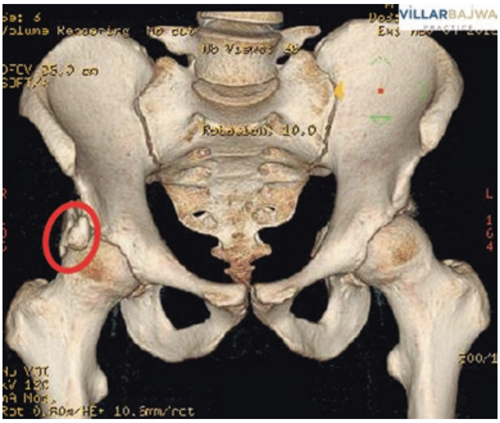

Fig. 6.1 A 3-D CT scan showing a Type-3 subspine impingement lesion of the right hip joint

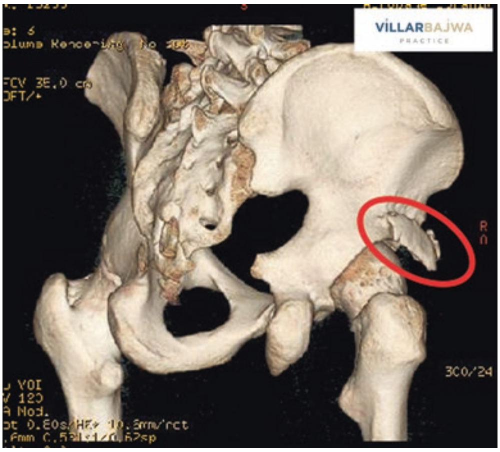

Fig. 6.2 Abnormal morphology of anterior inferior iliac spine (AIIS) with a Cam type impingement lesion noted on 3-D CT scan

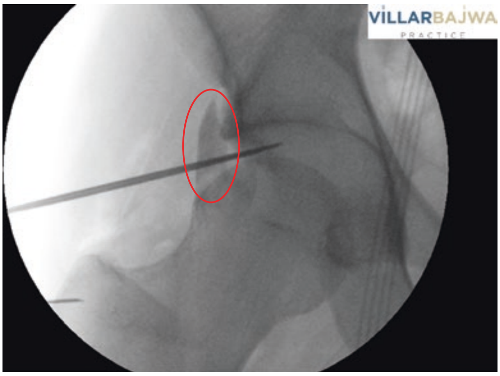

Fig. 6.3 Hip joint being accessed under fluoroscopic guidance while avoiding the overhang of the subspine impingement lesion

impingement lesion. Hip joint was stable with an intact ligamentum teres (Fig. 6.4). Chondrolabral damage was noted anterosuperiorly with full-thickness acetabular labral damage and grade 3 chondral delamination (Fig. 6.5). Retrolabral sulcus was developed at 12:30 on clock-face using RF while protecting the reflected head of the rectus. Acetabular labrum was not formally taken down but protected (Fig. 6.6). Impingement lesion was delineated sequentially with RF probe (Fig. 6.7). Careful recession of impingement lesion was undertaken using 4.5 mm burr at 8000 revs/min with suction on free-flow (Fig. 6.8). Position of the bur and impingement lesion was monitored with fluoroscopy (Fig. 6.9). Remnant of the over-hanging 'hook' of the impingement lesion was recessed under direct vision (Fig. 6.10) and confirmed on fluoroscopy (Fig. 6.11). Subspine area was assessed satisfactory decompression of the impingement lesion (Figs. 6.12, 6.13 and 6.14). Traction was applied again to deal with the intra-articular pathologies.

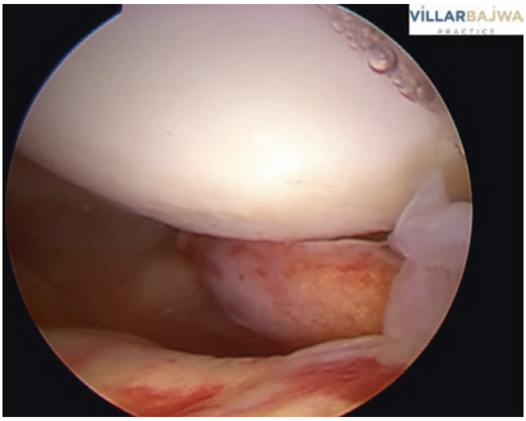

Fig. 6.4 An arthroscopic view of cotyloid fossa and an intact ligamentum teres

Fig. 6.5 An arthroscopic hook probe being used to define the chondrolabral disruption anterosuperiorly with adjacent chondral delamination of acetabular chondral surface

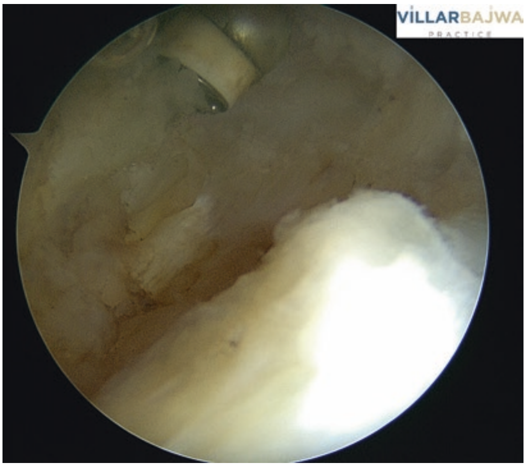

Fig. 6.6 Under arthroscopic control, perilabral sulcus being developed using a radiofrequency probe while maintaining the integrity of the acetabular labrum and the reflected head of rectus femoris

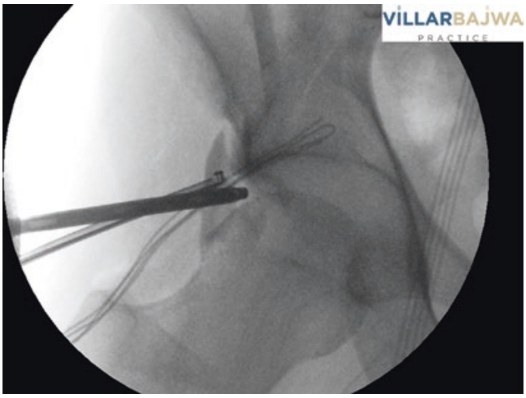

Fig. 6.7 A fluoroscopic image showing delineation of the subspine impingement lesion with radiofrequency probe and an arthroscope beyond the acetabular margin

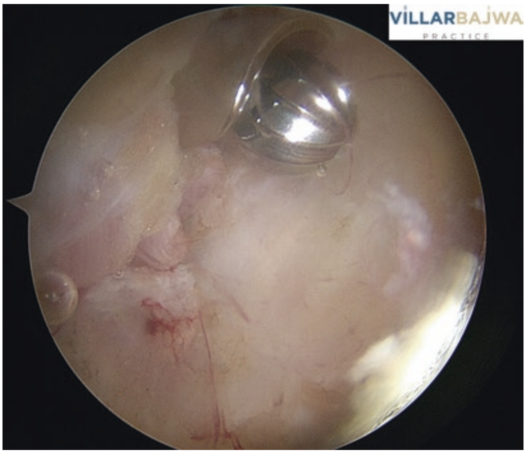

Fig. 6.8 An arthroscopic view showing a 5.5 mm high-speed spherical burr being positioned to recess the subspine impingement lesion

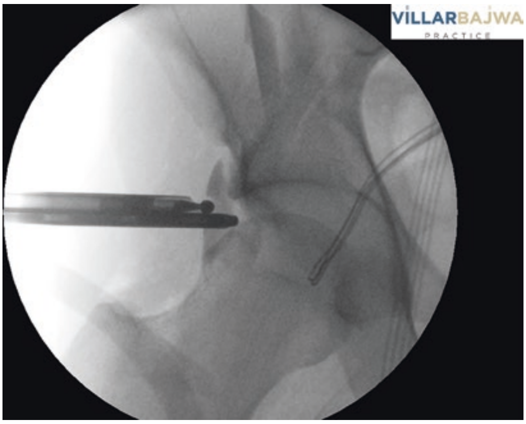

Fig. 6.9 Flouroscopic image of the spherical bur indenting through the subpsine impingement lesion while traction was reduced

Acetabular labrum was secured with all suture anchors (Figs. 6.15 and 6.16). Chondral delamination flap was stabilised with bone marrow harvested mesenchymal stem cells and fibrin scaffold via retrolabral approach (Figs. 6.17 and 6.18). Suture anchors were also placed for capsular repair but were not tied down at this stage. Hip joint was reduced. The final phase was to approach the peripheral compartment via superolateral portal and anterolateral portals without undertaking further capsulotomy. Cam impingement lesion was delineated (Figs. 6.19 and 6.20) and excised with a 5.5 mm burr and

Fig. 6.10 An arthroscopic view of the burr addressing the hooked part of the subspine impingement lesion

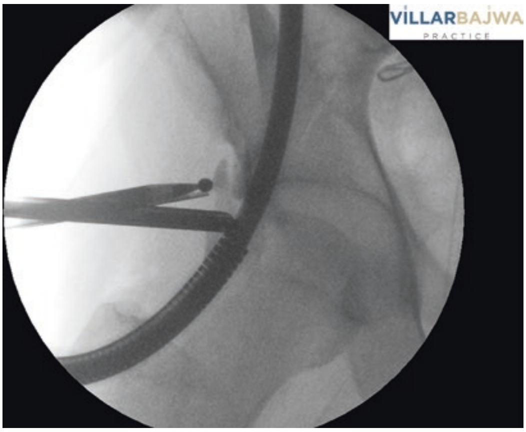

Fig. 6.11 Flouroscopic image confirming the position of the burr on the periphery of the subspine impingement lesion

Fig. 6.12 An arthroscopic view of the final stages of excision of the subspine impingement lesion

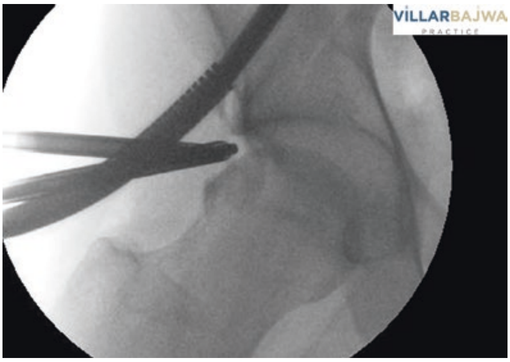

Fig. 6.13 Flouroscopic image to guide the final stages of excision of the subspine impingement lesion

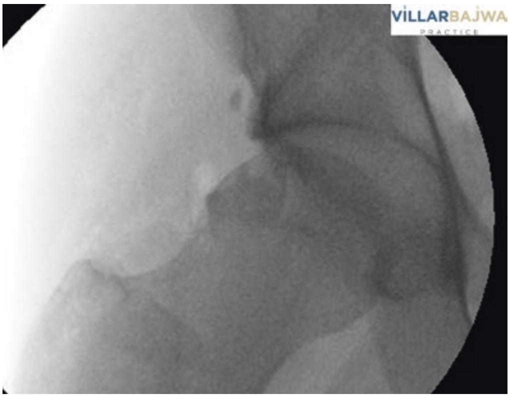

Fig. 6.14 Flouroscopic image evaluating the excision of the subspine impingement lesion

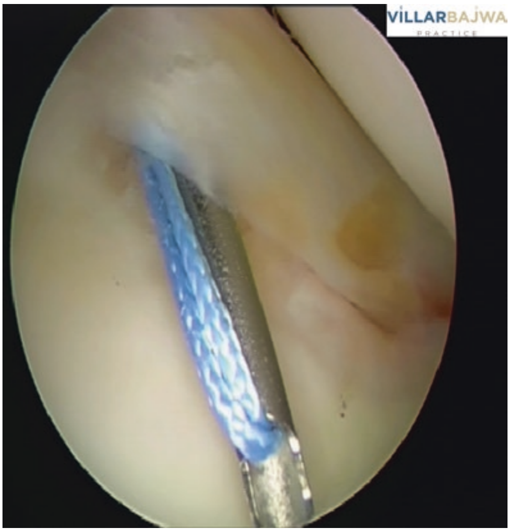

Fig. 6.15 A suture being placed to stabilize the acetabular labrum that was preserved during the recession of subspine impingement lesion

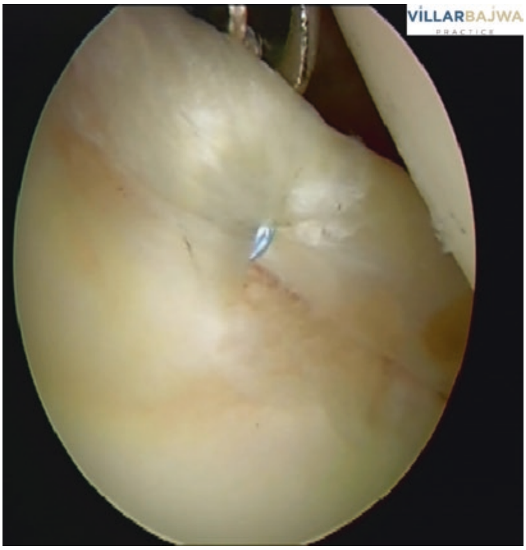

Fig. 6.16 An arthroscopic view of the labrum repair using an all-suture anchor. Note a patch of adjacent chondral delamination in the foreground

Fig. 6.17 An arthroscopic view of the needles being introduced into the hip joint in preparation to address the chondral delamination

8000 revs/min (Fig. 6.21). Pump pressure was kept less than 40 mmHg throughout to avoid excessive fluid extravasation. Capsular repair was completed with leg in 15°–20° of flexion using already-loaded suture anchors. Hip joint was instilled with hyaluronic acid and skin portals were closed with simple sutures.

Fig. 6.18 An arthroscopic view of the dry hip joint where chondral delamination repair is being addressed using bone marrow harvested mesenchymal stem cells

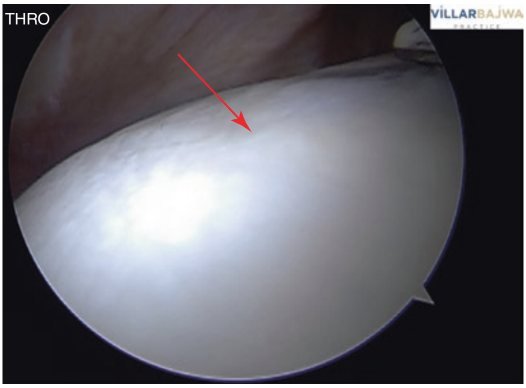

Fig. 6.19 An arthroscopic view of the Cam impingement lesion (red arrow) being viewed from the peripheral compartment

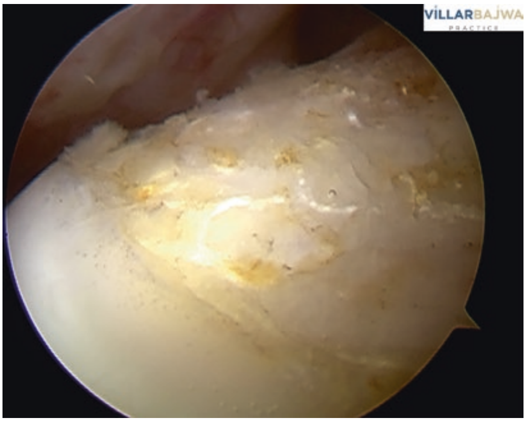

Fig. 6.20 An arthroscopic view of the Cam impingement lesion after soft tissues have been partly cleared with the radiofrequency probe

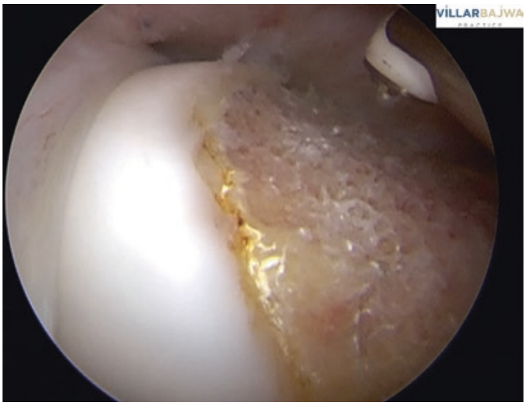

Fig. 6.21 An arthroscopic view from the peripheral compartment using superolateral portal that shows excision of Cam impingement lesion to augment the earlier subspine impingement excision. An intact labral seal is also visualized

Post-operatively the patient is kept partial weight bearing for 2/52 or until gluteal control is achieved. No brace is used. We aim to regain full weight bearing relatively early. Full range of flexion is allowed but extreme of external rotation is avoided for 4/52. Resisted hip flexion and knee extension are avoided for 10/52. A single dose of low-molecular-weight heparin (LMWH), combined with TED stockings (4/52) and early mobilisation, is used. No routine prophylaxis for heterotrophic ossification is used but may be considered in high-risk patients. Physical therapy programme is instituted on the day of surgery and a structured programme is followed for 4 months with increasing activity level. A milestone-based approach is used during the rehabilitation, leading to return to sporting function.

6.5 Discussion

Subspine impingement is a variant of femoroacetabular impingement and may coexist with AIIS impingement or exclusively as a ‘subspine’ phenomenon. Often there is associated soft tissue damage that might need addressing. Hence an arthroscopic approach is strongly recommended even if endoscopic plan is employed. In addition, the subspine impingement may present as part of a mixed impingement phenomenon where by a focal pincer and a cam impingement lesion might be present. A careful assessment of the individual patient is important including lumbo-pelvic assessment, status of mobility or hypermobility and functional demands, including the sporting needs. Soft tissue component of the impingement lesion must be appreciated, including any damage to the native hip joint, which should be addressed at the same time in a sequential fashion. An isolated subspine impingement with soft tissue damage can often be managed with biomechanical corrections and training modifications. Hence, the role of non-operative treatment is not to be overlooked. In refractory cases of subspine impingement, with careful patient selection and planning functional, arthroscopic treatment results are comparable to Cam or Pincer impingement. Milestone-based physical therapy programme that provides early restoration of movement and return to full weight bearing is encouraged.

Conflict of Interest None.

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7

Endoscopic Deep Gluteal Syndrome Techniques: Ischiofemoral Impingement Decompression

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7.1 Introduction

Ischiofemoral impingement syndrome (IFI) is an underrecognized form of atypical, extra-articular hip impingement defined by hip pain related to narrowing of the space between the ischial tuberosity and the femur. Narrowing of the ischiofemoral space leads to muscular, tendon, and neural changes [1, 2]. Since the first description of an impingement syndrome between the femoral lesser trochanter (LT) and the ischium by Johnson in 1977 [3], ischiofemoral impingement has been increasingly recognized as an overlooked cause of hip pain. A rubbing mechanism between the ischium and the lesser trochanter could lead to the development of quadratus femoris (QF) edema. The syndrome may occur acutely because of inflammation/edema or chronically because of fibrous tissue formation that traps the sciatic nerve (SN).

7.2 Etiology and Predisposing Factors

The ischiofemoral space should be understood as a gait-related dynamic area with several contributing and predisposing factors. A recent study about the effect of angular deformities of the proximal femur on impingement-free hip range of motion found that when increasing neck–shaft angles (≥135°) and femoral torsion (≥25°), ischiofemoral impingement occurred [4]. In native hips, IFI has been discussed as a result of marked coxa valga deformities [5]. Other authors have suggested excessive femoral antetorsion and other changes in pelvic anatomy in patients with IFI [6]. Gómez-Hoyos et al. [7] assessed the femoral neck version (FNV) and the lesser trochanter version (LTV) in 11 patients with confirmed diagnosis of IFI. No difference was found in mean LTV between groups; however, the mean

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Table 7.1 Potential etiologies and predisposing factors of ischiofemoral impingement (IFI) according to the pathophysiological mechanisms [8]

1. Primary or congenital (orthopedic disorders)
1.1 Coxa valga
1.2 Prominence of the lesser trochanter
1.3 Congenital posteromedial position of the femur
1.4 Larger cross section of the femur
1.5 Abnormal femoral antetorsion
1.6 Coxa breva
1.7 Variations of the pelvic bony anatomy
2. Secondary or acquired
2.1 Functional disorders
(a) Hip instability
(b) Pelvic and spinal instability
(c) Abductor/adductor imbalance
2.2 Ischial tuberosity enthesopathies
2.3 Traumatic, overuse, and extreme hip motion
2.4 Iatrogenic causes
2.5 Tumors
2.6 Other etiologies (genu valgum, leg discrepancy, pronated foot)

FNV (21.7° vs. 14.1°) was higher in symptomatic than in asymptomatic patients, with statistical significance. Isolated dynamic entrapment of the sciatic nerve by the quadratus femoris muscle (QFM), spasm, or anatomical variants has not been reported. A list of potential etiologies and predisposing factors of ischiofemoral impingement is presented in Table 7.1 [8].

7.3 Clinical Examination and Symptoms

- The clinical assessment of patients with IFI is difficult because the symptoms are imprecise and may be confused with other lumbar and intra- or extra-articular hip diseases, including deep gluteal syndrome [9].
- Patients typically present with mild to moderate nonspecific chronic and sometimes gradually increased pain in the deep gluteal region. This pain can be also located lateral to the ischium, in the groin and/or in the center of the buttock.
- Limited sitting time and limitation of physical activities including long-stride walking are frequent. Duration of these symptoms vary between months and several years and usually there is no precipitating injury (except trauma-related cases) [1, 10–12]. The specific physical examination test included the long-stride walking test and IFI test [8, 10, 13]. The injection test of the ischiofemoral space (IFS) has both a diagnostic and therapeutic function.

7.4 Medical Imaging

Although IFI is increasingly being discussed in the medical literature, it remains a poorly recognized condition because symptoms are often nonspecific. Hence, imaging plays an important role in its diagnosis and treatment. Patients presenting with unexplained buttock pain must be initially screened with lumbar and pelvic imaging to rule out spinal pathology and/or unusual pelvic masses.

- **Radiographs**: There are no specific radiographic findings for IFI. The IFS narrowing on radiographs is uncommon and has not been related to clinical findings or other imaging tests. Although chronic osseous changes of the lesser trochanter and ischial tuberosity may be present, it is uncertain whether chronic contact between them represents the cause. However, hip and pelvic radiographs are useful to diagnose osseous abnormalities that may cause acquired IFI or to depict other causes of pain [8].
- **Magnetic resonance imaging (MRI)**: Characteristic findings are a decreased ischiofemoral space compared to healthy controls (the ischiofemoral space measures 23 ± 8 mm and femoral space 12 ± 4 mm) and altered signals from the quadratus femoris muscle, which results in edema, muscular rupture, or atrophy [13, 14] (Figs. 7.1 and 7.2). However, soft tissue magnetic resonance imaging (MRI) signal abnormalities are present within the IFS in 9.1% of asymptomatic patients (edema in 1.4% and fatty infiltration in 7.7%) [15]. Unfortunately, the resting position of the limb that is required for routine MRI does not reproduce the conditions leading to instability in daily life. Moreover, there is ≥10% width difference between the right and left IF spaces

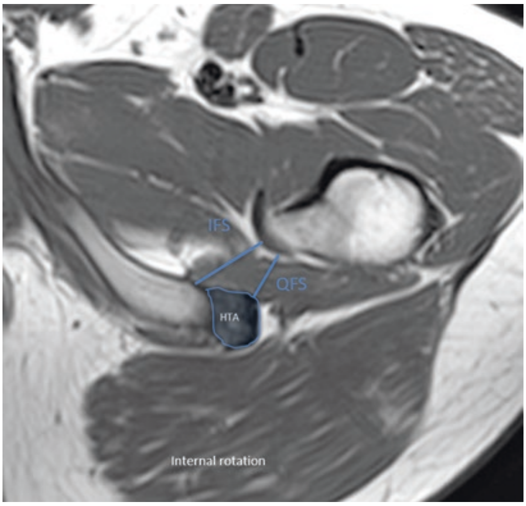

Fig. 7.1 Axial T1-weighted magnetic resonance (MR) image at the tip of the lesser trochanter (LT) in internal rotation shows normal left ischiofemoral space (IFS), quadratus femoris space (QFS), and hamstring tendon area (HTA). IFS is defined as the gap between the ischium tuberosity and the iliopsoas tendon, and the LT and QFS as the smallest gap between the superolateral surface of the hamstring tendons and the posteromedial surface of the iliopsoas tendon or the LT

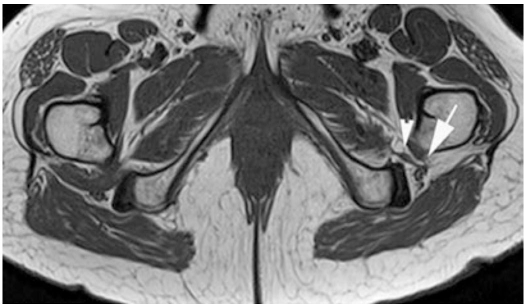

Fig. 7.2 Left deep gluteal syndrome secondary to chronic ischiofemoral impingement (IFI) in a 53-year-old woman. Axial proton density (PD)-weighted magnetic resonance (MR) image shows bilateral narrowing of the ischiofemoral space (IFS). On the left side, quadratus femoris muscle atrophy and a residual fibrous type-2 band (arrowhead) anchored to the sciatic nerve (arrow) are seen

in approximately half of asymptomatic individuals [15]. These measurements depend on the degree of hip rotation, adduction, and extension during MRI; therefore, the validity of these values remains unclear [16, 17]. Nevertheless, these studies are not invalid. Using a cutoff of ≤15 mm, a sensitivity of 76.9%, specificity of 81.0%, and overall accuracy of 78.3% have been reported. For quadratus femoris space (QFS), a cutoff of ≤10.0 mm resulted in 78.7% sensitivity, 74.1% specificity, and 77.1% overall accuracy [13].

7.5 Conservative Treatment

- Several management strategies have been proposed for relieving symptoms, although no definitive treatment has been recommended. Initial management should be conservative [8]. Several reports describe patients successfully treated with a nonsurgical algorithm, which can normalize the range of motion in the hip joint. Stretching exercises and strengthening of the spine musculature and the hip muscles are essential.
- The exercise program must be targeted to the external rotators of the hip, specially the quadratus femoris muscle (QFM) and abductor musculature, to adequately reduce pain and increase range of motion in the hip joint and increase its stabilizing effect on the hip. This approach may be essential for solving cases secondary to atrophy or related to instability of the hip, pelvis, and spine. Nonsteroidal anti-inflammatory medications and an infiltration test may be beneficial as an adjunct to the exercise program.
- Although the injection test is not always a definitive treatment, it is a nonsurgical alternative in selected patients that provides the palliative relief of symptoms. Most patients recognize the pain location when the needle is advancing into the IFS, and as an indicator of a successful injection, they experience a significant immediate postinjection decrease in symptomatology, which can last from 1 day to 9 months [18].

7.6 Operative Treatment

As a general guideline, only patients who have failed conservative measures are considered for operative treatment. The type of surgical procedure (open or endoscopic) depends on the clinical and imaging diagnosis. The response to targeted injections is helpful to predict the treatment success. Until recently, excision of the LT with an open approach had been recommended as a normal operative technique for IFI with a narrowed ischiofemoral distance [19]. Arthroscopic access to decompress the IFS, as an alternative to an open approach, has been recently described with high success rates because it managed to significantly improve clinical scores [10, 20–22].

7.6.1 Endoscopic Surgical Technique

7.6.1.1 Indications

- Entrapment injuries of the sciatic nerve at the level of the quadratus femoris
- Ischiofemoral impingement

7.6.1.2 Anatomy

- The quadratus femoris muscle (QFM) is a flat and quadrilateral muscle, situated within the subgluteal space of the hip [23]. The potential structures in danger are the medial and lateral femoral circumflex arteries, which course on the upper border of the QF muscle [24]. A cadaveric dissection study described that the medial circumflex artery was located on an average of 18 mm from the lesser trochanter (LT) [25].

7.6.1.3 Lesser Trochanter Approach

Due to the location of the LT, the arthroscopic procedure can be approached either anteriorly or posteriorly and with partial or complete resection of the LT. The goal of surgery is to reestablish a normal distance, which may not require a complete resection of the lesser trochanter. We agree with other authors that the posterolateral trans-quadratus approach seems to be the most appropriate route [10, 26, 27]. The anatomy of vascular structures suggests increased safety of posterior access to the lesser trochanter [28]. Another advantage of this approach is that it allows simultaneous assessment of the sciatic nerve and hamstring repair if needed. Ischioplasty when necessary can also be done with this approach. The aim of the osteoplasty of the posterior one-third of the lesser trochanter is to obtain an IFS of at least 17 mm, leaving non-impingement bone and the iliopsoas insertion intact. Partial resection without releasing all of the iliopsoas tendon insertions can potentially decrease the risk of stress fracture when compared with complete resection and this fact may be particularly important for high-performance athletes [10]. We will describe the posterior approach with partial resection. This approach in our hands have had favorable outcomes without any complications.

7.6.1.4 Patient's Position

- Supine or lateral position in a traction table, standard preparation for hip arthroscopy, no traction. May be performed concomitant to a hip arthroscopy of the central and/or peripheral compartments, if indicated.
- Leg is abducted to about 15–20° in order to open the interval between the trochanter and the iliotibial band (ITB) and the leg is internally rotated 20–40° or more to bring the lesser trochanter into the field of view (Fig. 7.3; Video 7.1).

7.6.1.5 Instruments/Equipment/Implants Required

- Arthroscopic shaver and burr.
- A 30–70° arthroscope, and in some cases or larger patients the use of an extra-longer arthroscope is required.
- Radiofrequency probe. The cannulas are opened to maintain the fluid flow, when utilizing the radiofrequency probe. Additionally, the temperature profile during activation of a monopolar radiofrequency device was found to be safe at a distance of 3–10 mm to the sciatic nerve during activation times of 3, 5 and 10 s [29]. The standard approach to vessel cauterization is a 3-s interval of radiofrequency activation, maintaining continuous irrigation.
- A blunt switching stick can be used to gently dissect and palpate the tissues to improve visualization.

Fig. 7.3 Patient's position: right hip. Supine position in a traction table, standard preparation for hip arthroscopy, no traction, and 20° of contralateral tilt. Leg is abducted to about 15–20° in order to open the interval between the trochanter and the iliotibial band and the leg is internally rotated 20–40°, for the same reason

- Fluoroscopy. Frequent use of intraoperative fluoroscopy will confirm the proper location of the endoscopic view.

7.6.1.6 Portals

The technique of endoscopic decompression of the sciatic nerve requires significant hip arthroscopy experience with familiarity with the gross and endoscopic anatomy of the subgluteal space [23]. The subgluteal space is the posterior extension of the peritrochanteric space, so entrance into this space is accomplished by portals traveling through the peritrochanteric space, which is between the greater trochanter and the iliotibial band. Different portals have been described to access the peritrochanteric space. Basically, we can divide these portals into two groups: (1) standard portals redirected to the peritrochanteric space (anterolateral, anterior, and posterolateral portals), and (2) portals described to access the peritrochanteric space [30] (proximal anterolateral accessory portal, distal anterolateral accessory portal, peritrochanteric space portal, and auxiliary posterolateral portal). Auxiliary distal portals at the level of the lesser trochanter (ischiofemoral impingement [IFI] portals) are crucial for performing this type of surgery [10] (Fig. 7.4).

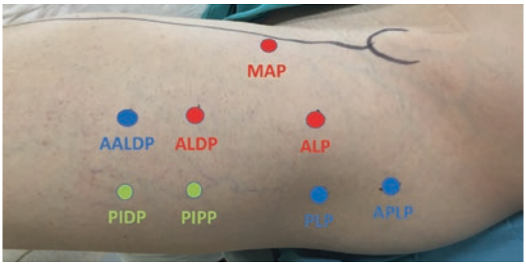

Fig. 7.4 Left gluteal region showing portal placement for subgluteal endoscopy. *MAP* midanterior portal, *AALDP* accessory anterolateral distal portal, *ALDP* anterolateral distal portal, *ALP* anterolateral portal, *PLP* posterolateral portal, *APLP* auxiliary posterolateral portal; for ischiofemoral impingement decompression, auxiliary distal portals at the level of the lesser trochanter (ischiofemoral impingement [IFI] portals) are crucial for performing this type of surgery, *PIDP* posterior ischiofemoral distal portal, *PIPP* posterior ischiofemoral proximal portal

7.6.1.7 Posterolateral Trans-Quadratus Approach Technique

Aim

- Osteoplasty of the posterior one-third of the lesser trochanter to obtain an IFS of at least 17 mm, leaving non-impingement bone and the iliopsoas insertion intact.

- Sciatic neurolysis. Chronic inflammatory changes and adhesions causing scar tissue between the muscle and the sciatic nerve result in entrapment during hip motion. In these cases, endoscopic neurolysis of the sciatic nerve is required.

Approach to Peritrochanteric Space

- First, the peritrochanteric space portal is established. A 5.0-mm metallic cannula is positioned between the ITB and the lateral aspect of the greater trochanter, and the tip of the cannula can be used to sweep proximal and distal to ensure placement in the proper location. Fluoroscopy can also be used to confirm that the cannula is located immediately adjacent to the greater trochanter at the vastus ridge.

Orientation

- The arthroscope is placed perpendicular to the patient and looks in a distal direction in order to identify the gluteus maximus tendon inserting into the linea aspera of the femur posteriorly (Fig. 7.5).

Procedure: Step-by-Step Description of the Technique

- The deep gluteal space is endoscopically accessed using three to four portals: anterolateral, posterolateral, and auxiliary distal at the level of the lesser trochanter (ischiofemoral impingement [IFI] portals). The anterolateral portal is used for access to obtain visualization. The posterolateral portal and auxiliary distal ischiofemoral portals are used for the introduction of a probe, arthroscopic burr, curved retractors, or the arthroscope (Fig. 7.6).
- The main surgical steps are: peritrochanteric inspection and bursectomy; identification of quadratus femoris muscle and sciatic nerve; and palpation of the lesser trochanter with a blunt probe under fluoroscopic control.
- Access to the lesser trochanter is achieved via a small window in the quadratus femoris muscle (Fig. 7.7).
- This window is located between the medial circumflex femoral artery (proximal) and first perforating femoral artery (distal) (Fig. 7.8). To protect the vessels, preservation of the proximal and distal muscle is recommended.
- Assessment of the sciatic nerve (SN) within the subgluteal fat must be done to perform neurolysis in the case of entrapment. Identifying and decompressing the SN, which is often concomitantly involved, is critical to achieving optimal results.

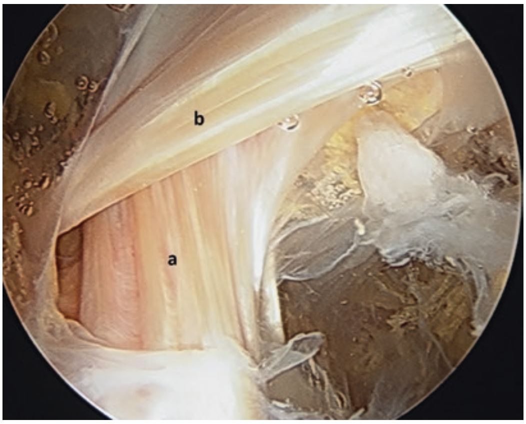

Fig. 7.5 Endoscopic view of left hip. Visualizing through the peritrochanteric portal, the examination begins at the gluteus maximus insertion at the linea aspera. (**a**) Gluteus maximus insertion; (**b**) Vastus lateralis

Fig. 7.6 Right gluteal region showing portal placement for ischiofemoral impingement decompression: scope in the anterolateral portal; radiofrequency probe in the anterolateral distal portal; rod in the ischiofemoral impingement (IFI) portal; cannula in the auxiliary posterolateral portal

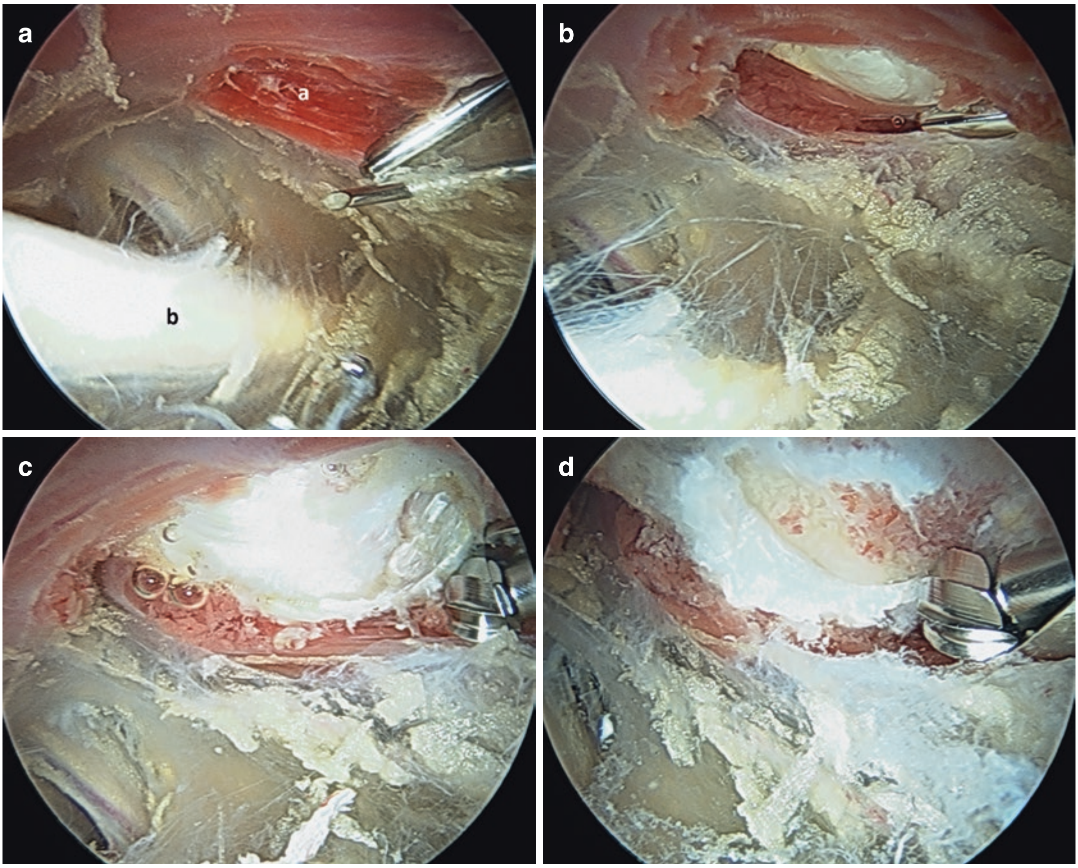

Fig. 7.7 (**a**–**d**) Right hip: endoscopic view showing the access to the lesser trochanter. This access is achieved via a small window in the quadratus femoris muscle. Quadratus femoris muscle (**a**); Sciatic nerve (**b**)

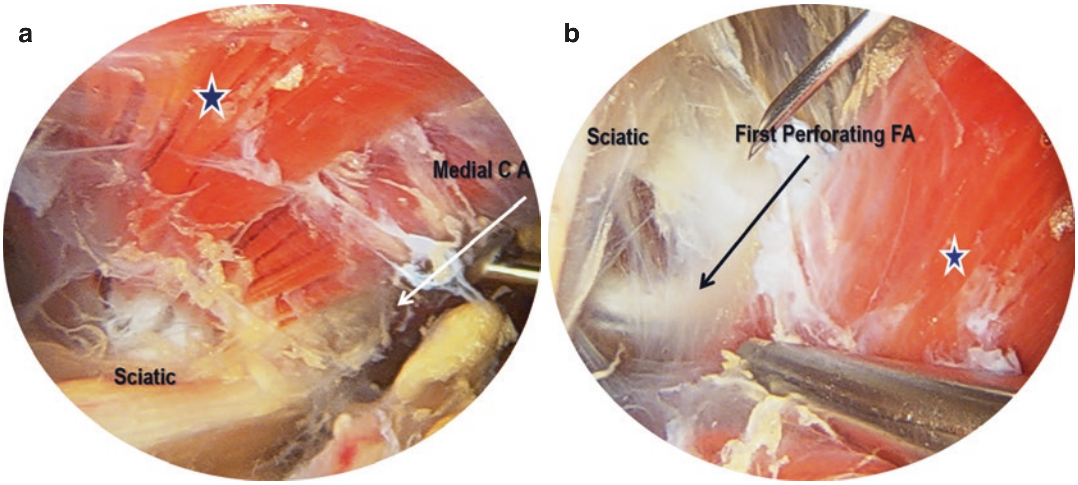

Fig. 7.8 (**a**, **b**) Left hip: endoscopic view showing the space for the window to access the lesser trochanter between the medial circumflex femoral artery (FA; proximal) and first perforating femoral artery (FA; distal). Star: Quadratus femoris muscle

- QFM debridement is indicated when tears are present. If advanced degenerative changes exist, complete muscle resection may be effective.
- Osteoplasty of the posterior one-third of the lesser trochanter is then carried out, aiming for an ischiofemoral space of at least 17 mm and leaving non-impingement bone and most of iliopsoas insertion intact (Fig. 7.9). This resection is done by progressive and careful abrasion. The posterior femoral cortex will define the level of resection. This particular subperiosteal approach maintains the insertion of the iliopsoas tendon on the anterior portion of the lesser trochanter and the femur.
- Confirm ischiofemoral space decompression with intraoperative endoscopy and fluoroscopy. Intraoperative dynamic tests are recommended to avoid under- or over-resection (Video 7.2).
- If hamstring repair is necessary, partial tearing debridement with an oscillating shaver and suture (one suture anchor per centimeter of detachment) is required.

Postoperative Care and Rehabilitation

- Initial postoperative instructions during the first 4 weeks include crutches and partial

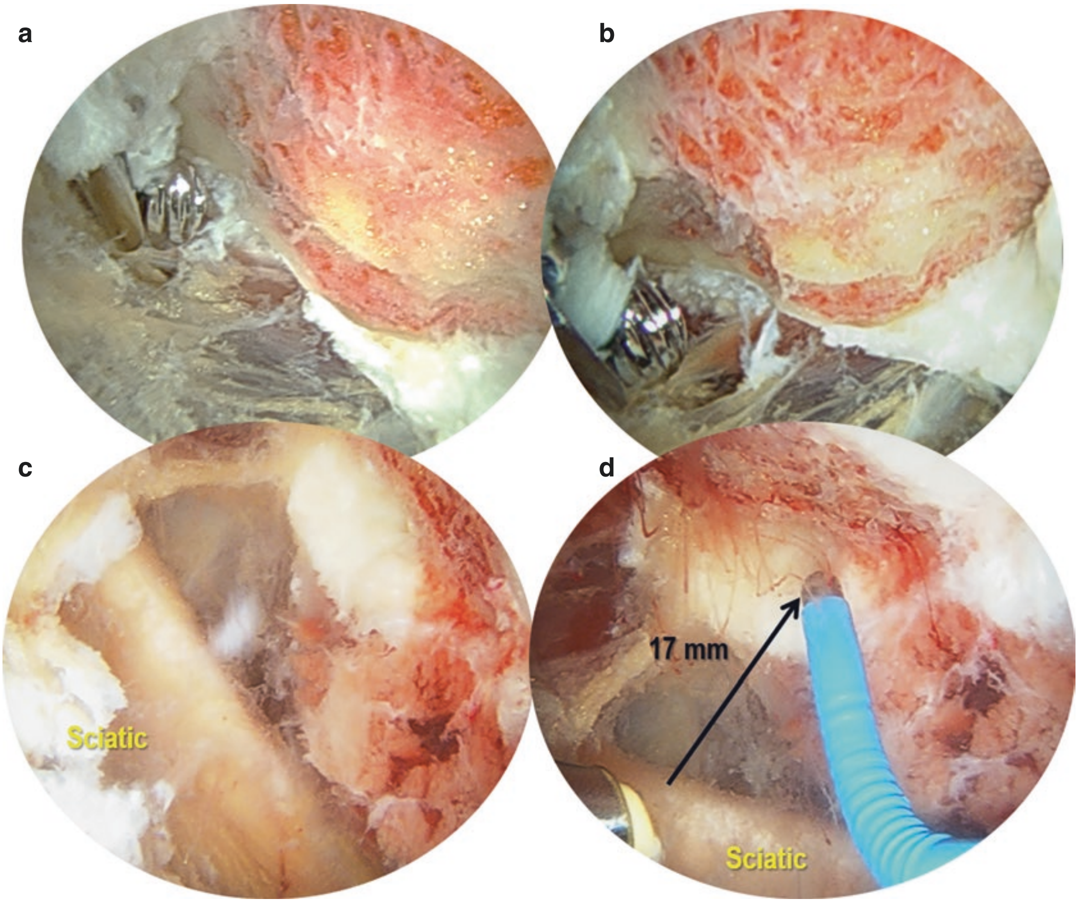

Fig. 7.9 Left hip: endoscopic treatment in patients affected by ischiofemoral impingement (IFI). Intraoperative endoscopic images show the lesser trochanter before (**a**, **b**) and after (**c**, **d**) performing the resection. The aim of the osteoplasty of the posterior one-third of the lesser trochanter is to obtain an ischiofemoral space (IFS) of at least 17 mm leaving non-impingement bone and the iliopsoas insertion intact

weight bearing and neutral hip flexors stretching. Important milestones for an adequate postoperative recovery are lumbopelvic alignment and stabilization to control hip extension and abductor strengthening; then, avoiding lower pelvic drop or excessive adduction of the lower limb during weight bearing [31].

- No active lifting of the leg is recommended in order to protect the remaining tendon insertion.
- Nerve glides can be applied under the limit of pain.

7.7 Avoiding Pitfalls and Complications

- Complications have involved hematomas brought on by early postoperative use of nonsteroidal anti-inflammatory drugs (NSAIDs) with excessive postoperative activity. We use tranexamic acid with the same protocol as in hip and knee arthroplasty to prevent this complication and the use of postoperative drain 18 h to control a possible bleeding.
- Scar formation around the sciatic nerve can be controlled with antiadhesion gels in order to prevent painful scar neuropathy.
- Excess bone debris must be evacuated to minimize heterotopic ossification risk.

7.8 Results

- Several treatment strategies have been reported for IFI, and most of them have good short- to medium-term outcomes with a low rate of complications. A systematic review by Nakano et al. found 17 relevant papers. No comparative studies were included in the final records for qualitative assessment, which means all the studies were case series and case reports. Eight studies (47.1%) utilized nonsurgical treatment including injection and prolotherapy, followed by endoscopic surgery (five studies, 29.4%) then open surgery (four studies, 23.5%). Mean age of the participants was 41 years (11–72 years). The mean follow-up was 8.4 months distributed from 2 weeks to 2.3 years. No complications or adverse effects were found from the systematic review. Of the 17 studies in the systematic review, five studies reported on the use of endoscopic surgical management [10, 20–22, 32]. All of them reported on partial or entire resection of the LT and good short- to medium-term outcomes (from 4 months to 2.3 years) without any neurological or vascular complication [33].
- We have reviewed and evaluated our results of 14 patients (15 hips; 14 females; 9 right, 6 left) treated in our clinic for ischiofemoral impingement and endoscopic posterolateral trans-quadratus approach decompression of the lesser trochanter between November 2011 and April 2018. Mean age was 38 years (20–52 years). The mean modified Harris Hip Score increased from 58 points preoperatively to 92 points at the final follow-up. No complications or adverse effects were found.
- Most of the studies lacked quantitative metrics in their analysis and hence quantitative conclusions could not be drawn for recommending one treatment strategy over another, so future studies should address comparative effectiveness of the various treatment options in this arena [33].

7.9 Conclusion

IFI is an underrecognized condition and its etiology is multifactorial. The endoscopic approach seems to have many advantages when compared with the open approach especially in terms of the extent of soft tissue damage, but it requires high technical skills.

Tips and Tricks

- In ischiofemoral syndrome the aim of the osteoplasty of the posterior one-third of the lesser trochanter is to obtain an IFS of at least 17 mm, leaving non-impingement bone and the iliopsoas insertion intact.
- Visualizing through the peritrochanteric portal, the examination begins at the gluteus maximus insertion at the linea aspera.
- Access to the lesser trochanter is achieved via a small window in the quadratus femoris muscle located between the medial circumflex femoral artery (proximal) and first perforating femoral artery (distal).
- Use tranexamic acid with the same protocol as in hip and knee arthroplasty to prevent hematomas; use postoperative drain 18 h to control a possible bleeding.
- Intraoperative dynamic tests are recommended to avoid under- or over-resection.

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Os Acetabuli: Removal or Fixation

8

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8.1 Introduction

The os acetabuli (OSA) is a bone fragment located at the acetabular rim. Albinus [1] was the first to detect in 1737 a separate bone nucleus between the large main ossification centers of the pelvis, which was then called os acetabuli by Krause [2] in 1876. In 1909, Lilienthal supposed that it could be a secondary center of ossification that has not completed fusion with the other pelvic bones [3]. Zander [4] in 1943 described the os acetabuli as a new bone nucleus appearing at the beginning of the process of synostosis of the ilium, the ischium, and the pubis. Zander and Pöschl [4, 5] state that the anterior bone nucleus between the ilium and the pubis corresponds to the os acetabuli. It appears as a flat bone at the anterosuperior rim at the age of 9–14, and it fuses with the other pelvic bone at the age of 18–24, but very occasionally it may persist as an independent bone throughout life. Ogden defined this entity as secondary ossification within the triradiate cartilage [6]. Ponseti described three secondary acetabular ossification centers in the hyaline acetabular cartilage that appear at puberty [7] of which the os acetabuli represents the epiphysis of the os pubis, forming the anterior wall of the acetabulum. The os acetabuli is separated from the bone by the growth plate that runs parallel to the joint surface. Hyaline cartilage covers the articular side of the os acetabuli, and the labrum is attached at the periphery.

More recently, some authors have described some os acetabuli as fatigue fractures (rim fracture [RF]) due to instability in hip dysplasia or due to repetitive edge stresses in femoroacetabular impingement (FAI) [8–10]. Usually, the involved FAI type is a cam deformity. Sometimes an acetabular retroversion or an anterior over-coverage further increases the stresses on the acetabular rim.

The terminologies os acetabuli and rim fracture often overlap, and it is not clear for the most if they are the same pathology at different stages or real different pathologies (Fig. 8.1). Martinez et al. [8] claim that they are different pathologies and the orientation of the fragment may help differentiate the two entities. The presence of a bone fragment with labrum attached to it and covered with cartilage on the inferior surface is both consistent with an unfused secondary ossification center and a pseudarthrosis of an acetabular rim fracture. A true os acetabuli is of cartilaginous growth plate origin and is oriented parallel to the joint surface. An acetabular rim fracture, instead, has a vertical separation line perpendicular to the joint surface [8].

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Fig. 8.1 Pelvic anteroposterior (AP) views of a young male patient with concomitant rim fracture (RF) on the right hip and os acetabuli (OSA) on the left hip

Also, the gap between secondary and primary ossification center is filled with the cartilage of the growth plate, in contrast to a pseudarthrosis, where the gap is filled with connective tissue. This condition also needs to be differentiated from the amorphous calcifications of the labrum. Jackson et al. [11] noted how calcifications differ from os acetabuli on imaging, as the first is smaller in size and do not show evidence of trabecular bone or cortical margins.

8.2 Epidemiology

Martinez et al. [8] found an os acetabuli/rim fractures prevalence of 3.6% in a consecutive group of femoroacetabular impingement. Jackson et al. [11] identified an os acetabuli in 94 patients (5%) at the time of arthroscopy for intra-articular hip disorders. In a study by Singh and O'Donnell [12], the prevalence of the os acetabuli was 7% in a cohort of professional football player undergoing hip arthroscopy. They also found that all the patients with an os acetabuli have an associated labral tear. In a retrospective study of patients undergoing hip arthroscopy for FAI, the os acetabuli was found with a prevalence of 7.7%. In the study, 95% were male patients, and there was an association of 100% with a cam-FAI morphology [13]. In literature, this condition is classically seen in healthy, young, and sporty males, involved in physically demanding activities [8, 11, 12, 14–16].

8.3 Physical Examination

Physical examination findings are similar to those found in patients with FAI syndrome, as patients typically present with anterior hip and groin pain that increases with sport activity, a positive flexion adduction internal rotation anterior impingement test, a positive flexion abduction external rotation test, and limited internal rotation and flexion [17]. Some patients may also present with pain and discomfort during abduction of the hip, which creates impingement of the femoral head–neck junction against the bone fragment.

8.4 Imaging

The radiologic examination will confirm the presence of the OSA. To fully characterize the femoral and acetabular anatomy, anteroposterior (AP) pelvis, false profile, and Dunn [18] views of the hip should be obtained. Assessment of the lateral center-edge angle (CEA), anterior CEA, and Tönnis angle should also be evaluated [19] with and without the os acetabuli.

Computed tomography (CT) scans are useful to assess the extension of the os and its relationships with the anterior inferior iliac spine, and to plan the surgical intervention, especially in terms of portal placement. A CT measurement of the os acetabuli/rim fracture is also very useful to decide whether to remove or fix the fragment and, in the case of fixation, the diameter and the number of the screws.

Magnetic resonance imaging (MRI) and magnetic resonance arthrography (MRA) is performed adjunctively to rule out cartilage defects, labral injuries, and, for some authors, to differentiate whether it is a real os acetabuli or a rim fracture [8]. MRI/MRA are also fundamental to rule out subchondral cysts and/or subchondral acetabular edema, a potential limit for conservative surgery.

8.5 Treatment

Treatment of an os acetabuli/rim fracture, for instance, removal or fixation, should be carefully planned. Specific intervention (Table 8.1) depends on multiple factors, including the size of the fragment, the degree of hip instability in case of removal, and the presence of risk factors for a poor outcome [8]. In dysplastic patients or patients where removal will result in instability or iatrogenic dysplasia, reduction and fixation is indicated [14]. In this regard, when the removal of the fragment will lead to a CEA of less than 25° on AP pelvis and less than 20° on a false-profile view, internal fixation is recommended [20]. Larson et al. [16] hypothesize that simultaneous correction of the impingement and the fragment fixation will eliminate the shearing forces, allowing the fragment to heal.

Table 8.1 Tips and tricks of os acetabuli treatment

Check for residual dysplasia	If the OSA/RF removal will lead to a CEA <25° on AP pelvis or <20° on a false-profile view
Check OSA/RF from inside/outside	The gap between the acetabular rim and the OSA/RF may not be visible from the articular side
Check OSA/RF stability	If small and very unstable can be more easily elevated than milled/trimmed
Do not violate the labrum during removal	It should be then resutured
Femoral osteoplasty	A femoral osteoplasty is often performed before fragment trimming/fixation
Screw type/number	Depends on the fragment size. Standard or headless screws. A washer may be used
Stable fixation	Lag screw technique or partially threaded screws are recommended
Avoid fragment fracture or malalignment	A central portion of the os and the appropriate location on the acetabular rim should be planned
Avoid fragment rotation	Use two parallel guidewire during screw tightening
Choose the right angle for fixation	An anterolateral accessory (DALA) portal is better Be helped by the aid of fluoroscopy
Protect the external iliac vessels	Guidewires should be angled posteriorly
Avoid loss of the screw	Attach a suture thread around the head of the screw. It can be used also for labral resuture
Check fragment compression/stability	With dynamic assessment and fluoroscopic views

8.5.1 Os Acetabuli Removal

When the removal of the fragment does not produce instability or under-coverage, the os acetabuli should be removed. Following the evaluation of the central compartment with a 70° arthroscope under traction, with the use of a shaver and a radiofrequency device, adhesions between the capsule and labrum are separated to access the recess and identify the os acetabuli. It is important to remember that the articular cartilage is often continuous and that the gap between the acetabular rim and the OSA/RF is not visible from the articular side. When the os acetabuli has been identified, its stability is assessed with a probe or an arthroscopic hook. The traction can be released.

The os acetabuli can be either elevated (Fig. 8.2) and excised with a grasper or trimmed with a burr [13]. Care should be taken not to violate the articular cartilage and the labrum, which

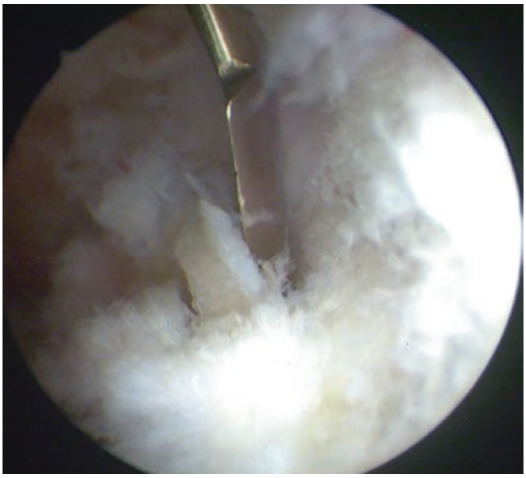

Fig. 8.2 An arthroscopic view of a left hip obtained during the release of an os acetabuli (OSA) using an arthroscopic bone elevator

Fig. 8.3 Preoperative and postoperative hip anteroposterior (AP) views of a patient treated with an arthroscopic os acetabuli/rim fracture (OSA/RF) excision

should be then sutured. For this reason, trimming should be preferred (Fig. 8.3).

8.5.2 Os Acetabuli Fixation

Epstein and Safran [14] were the first to describe the arthroscopic fixation of the rim fracture with two 4.5 mm cannulated screws in 2009. Other authors have also published case reports and technical note on arthroscopic fixation of an os acetabuli [15, 16, 21–23].

Screw size and number depends on the fragment size. Some authors prefer headless screws to avoid the intracapsular presence of the screw head. However, it is essential to obtain stable fixation and compression. Lag screws or partially threaded screws are recommended. A washer may be used [13]. Pérez Carro [21] published a technical note in 2017 describing a concomitant os acetabuli and labral fixation through the same screw. In his technique, a suture is attached to the proximal part of the screw (suture on screw) and is used for labral repair adjacent to the rim fracture. There is no consensus in the literature on whether it is necessary to debride the area of fibrous tissue between the os acetabuli and the acetabular rim before fixation. Some authors [15, 16] suggest perforations with k-wire at the docking site to promote healing.

While preparing the fixation, the traction is released and the os is partially trimmed, if needed, using an arthroscopic burr. Care should be taken to preserve the cartilage and the labrum. A femoral osteoplasty is also often performed at this time. Dynamic direct evaluation and fluoroscopy are used to assess the resections. After preparation of the bone bed, the traction is reapplied and the os is secured in place using a guidewire for a partially threaded cannulated screw. A second guidewire could be placed parallel to the first one to avoid rotation of the os during tightening of the screw and for the placement of a second screw if needed. Guidewires are generally placed through a distal anterolateral accessory (DALA) portal, with the aid of fluoroscopy. A central portion of the os and the appropriate location on the acetabular rim should be chosen. It is always important to check the central compartment for eventual penetration of the guidewires. As described by Epstein [14], the guidewires should be angled posteriorly to protect the external iliac vessels. The pilot hole is then drilled unicortically with the appropriate drill bit, with the use of arthroscopy and fluoroscopy. The cannulated screw is then advanced to secure the rim fragment in place (Fig. 8.4). A long screwdriver is essential to allow a secure and safe fixation. The compression achieved could be checked with arthroscopic and fluoroscopic views. It is recommended to attach a suture thread around the head of the screw to avoid loss of the screw in the soft tissues or within the hip joint. As described by Pérez Carro [21], the limbs of the suture can be used to suture the

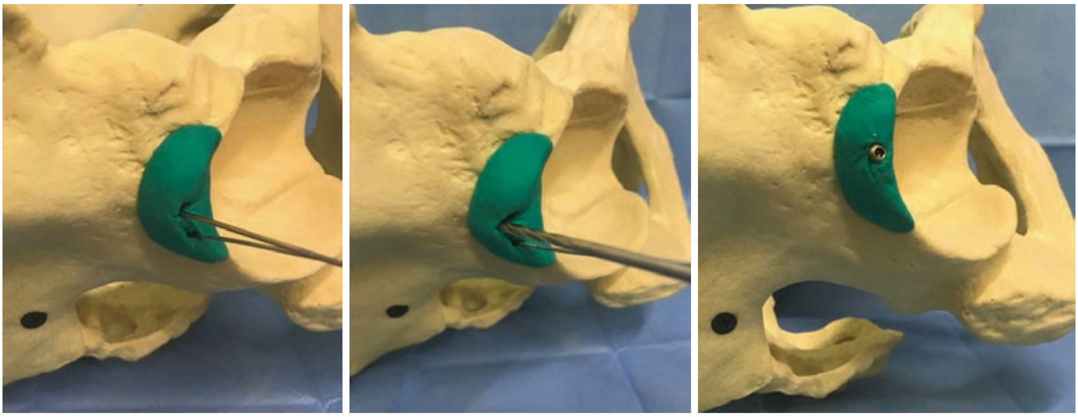

Fig. 8.4 Different stages of an os acetabuli/rim fracture (OSA/RF) fixation with a single screw. First, two guidewires are inserted to fix the bony fragment. A pilot hole is drilled with a cannulated drill bit. A screw is then fixed in the middle of the fragment

labrum when the screw is placed. Once the os is reduced and fixed, dynamic assessment is carried out to confirm that the fixation remains stable.

8.5.3 Postoperative Rehabilitation

The postoperative rehabilitation is patient and pathology specific and depends on concomitant procedures. Stationary bike with no resistance is started the first day after surgery to prevent adhesions, or continuous passive motion is indicated for 3 h a day [13]. Patients remain non-weight bearing for 4–6 weeks, and the range of motion is limited in flexion and external rotation for the first 6 weeks. Heterotopic ossification prophylaxis is also indicated for 3 weeks after surgery.

When the patient has progressed to full weight bearing and achieves full range of motion, strengthening exercises are recommended. Full activity is allowed between 3 and 4 months after surgery, once the healing of the os acetabuli has been checked with conventional radiology [14–16, 21].

8.5.4 Results

In literature, os acetabuli fixation has obtained excellent results with patients returning at their activity level at a mean of 4 months after surgery [14–16, 21]. The postoperative modified Harris Hip Score (mHHS) improved almost to 100, and the visual analogue scale (VAS) decreased significantly.

Giordano et al. [24] hypothesized that patients with concomitant FAI and OSA/RF might have better outcomes than other FAI patients after arthroscopic treatment. However, they could not demonstrate any statistically significant differences at minimum 2-year follow-up.

In literature [20], a case of early joint degeneration has been reported 10 months after os acetabuli removal in a 42-year-old woman with a lateral CEA of 15° preoperatively. A total hip arthroplasty was then required.

In general, results of the os acetabuli removal, with the right indication, are very encouraging [13, 25–27].

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9 Arthroscopic Core Decompression and Cell Therapy

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9.1 Introduction

Nontraumatic osteonecrosis of the femoral head (ONFH) typically affects relatively young, active patients and frequently results in considerable loss of function [1]. Osteonecrosis (ON) is derived by the Greek words osteo, meaning bone, and necrosis, death. The exact pathophysiology of nontraumatic ON is not thoroughly understood and various "incriminating" factors such as vascular insult, fat emboli, and increased intraosseous pressure have been proposed. If left untreated, the necrotic area of the femoral head could collapse resulting in arthritic changes in approximately 60–70% of the patients [2, 3].

Treatment is based on a number of parameters, such as lesion characteristics (size, the presence of collapse at the time of diagnosis, acetabular involvement), patient's age, and comorbidities [2, 4]. The optimal treatment modality has not yet been identified. Several algorithms of medical and surgical treatments have been developed to delay its progression, with variable success [5]. Surgically, total hip replacement (THR) is the most frequent intervention for post-collapse treatment, and core decompression (CD) is the most commonly performed procedure for symptomatic, pre-collapse cases [6]. Historically, THR for osteonecrosis (ON) had poor results, attributed to the young and active character of the patients and possibly due to chronic abductor inefficiency secondary to the index disease. During the 1980s and early 1990s, studies reported high failure rates [7, 8]. More recent reports and systematic reviews show that the introduction of newer implants and better surgical technique consistently deliver better clinical and implant survival results in comparison to the initial papers [9, 10]. The fact though remains that we are dealing with mostly young patients, so the possibility of failure and revision of the THR constitutes a reality. As a result, there has been an increased focus on early interventions for ONFH aimed at preservation of the native articulation. During early-stage disease, the most common joint preserving procedure performed is CD aiming to increase blood flow to the necrotic area by reducing the intraosseous pressure, alleviating pain, and improving function and inflammatory cell infiltration into the affected areas [5, 6].

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This chapter will focus on arthroscopically assisted CD techniques and discuss cell-based therapies that attempt to improve surgical outcomes. This recent focus on biology is based on the hypothesis that the harvested cells injected or embedded into the necrotic zone of the femoral head (FH) will repopulate the lesion, restore the local cell population, and enhance regeneration and remodeling [11, 12].

9.2 Core Decompression (CD)

Core decompression (CD) is the most common procedure performed for small- or medium-sized lesions, especially at the pre-collapse stage [13, 14]. It is a generic term that is often accompanied with supplemental procedures (vascularized or non-vascularized grafts, injection of cells, grafting, electrical stimulation, etc.) [15]. CD can be technically demanding, requiring intraoperative biplanar imaging for proper placement of the core drill to the necrotic lesion [13].

During the last decade, the management of hip pathologies has progressed to less invasive techniques. Hence, hip arthroscopy has found its place in the management of ON. It can be of value assessing the joint, and also addressing mechanical pathology (chondral flap lesions, labral tears, loose bodies, cam deformity, etc.) commonly found in these hips. It can also help in a more technical manner by assisting the proper placement of the drill during CD [16].

Theoretically, traction and irrigation pressure during arthroscopy could compress the terminal circulation of the femoral head, resulting in worsening of the underlying pathology of ON. However, only a handful of ON cases have been documented following hip arthroscopy suggesting that this is more a theoretical concern than a true clinical problem [17]. But, since the actual effect of irrigation pressure and traction in the circulation of the femoral head is not known in the already compromised environment of ON, it is our practice to utilize intermittent traction only when working in the central compartment and to use minimal irrigation pressure (pressure controlled at 40 mmHg).

9.3 Retrograde CD Technique

During hip arthroscopy for ON, an area of the femoral head is clearly identified where chondral softening or chondral irregularity is seen. This corresponds to the underlying necrotic lesion [16, 18]. Gentle pressure with a probe can cause the articular cartilage to buckle over the infarcted segment and to spring back to its original state upon release of the pressure. This is considered to be a positive “ballottement” test and suggests softening and lack of subchondral support [18]. Identification of this lesion can supplement CD retrograde drilling by giving two points of reference for aiming the drill in the center of the necrotic lesion—one arthroscopic and one fluoroscopic—thus enhancing our accuracy.

CD is performed percutaneously. A small stab incision is made on lateral proximal thigh through which a guiding pin is introduced and directed toward the area identified by arthroscopy under fluoroscopic guidance. Placement and trajectory of the guide pin is verified on both the anteroposterior (AP) and lateral views. Since the drilling is done under direct vision, it secures the femoral head from over-penetration by the drill and cartilage damage. An 8–10 mm cannulated reamer is over-drilled by the guide pin (Fig. 9.1a, b). The reamer should be kept at least at a 3 mm distance to the subchondral bone. Following the drilling, the necrotic lesion is cleared using a long sharp curette. Fluoroscopic guidance is useful at this stage, helping to estimate the amount of necrotic lesion cleared (Fig. 9.1c).

Placing the arthroscopy camera in the bone canal drilled (bone endoscopy) can also verify the correct placement of the bone channel during core decompression since the appearance of “white” necrotic bone confirms the correct placement [16, 19].

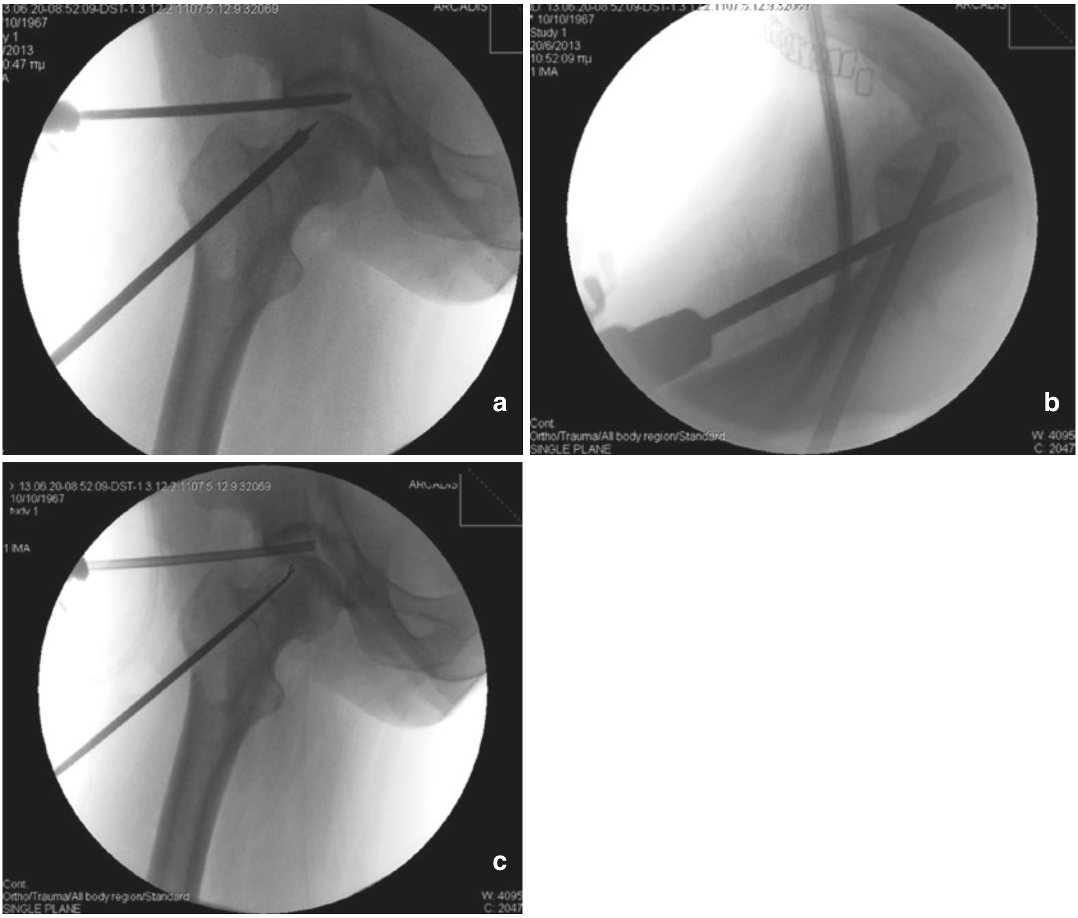

Fig. 9.1 (**a**, **b**) Arthroscopic-assisted core decompression retrograde drilling for osteonecrosis (ON). Intraoperative views on (**a**) antero-posterior (AP) and (**b**) lateral. (**c**) Arthroscopic-assisted curettage of the necrotic lesion

9.4 Head–Neck Junction CD Technique

A modification to the retrograde CD was proposed by Mont where FH decompression is performed through a window at the head–neck junction (trapdoor technique) [20]. However, the procedure as initially described requires extensive dissection and it is technically demanding [15].

In a less invasive fashion, CD drilling can be guided arthroscopically under direct visualization by inserting the drill via the peripheral compartment through the anterior or an auxiliary portal in the direction of the necrotic lesion. It is an area familiar in hip arthroscopy since it is the area where the cam lesion is resected [21] (Fig. 9.2a, b).

With the head–neck junction CD, we lose the benefit of the two-point drill guidance of arthroscopic-assisted retrograde CD since we lose site of the chondral softening lesion, but we have the benefit of being less invasive. The area of the necrotic lesion can be easily reached by moving the hip. In general, the antero-inferior area of the FH is best addressed with the hip in flexion and external rotation, and the superior-

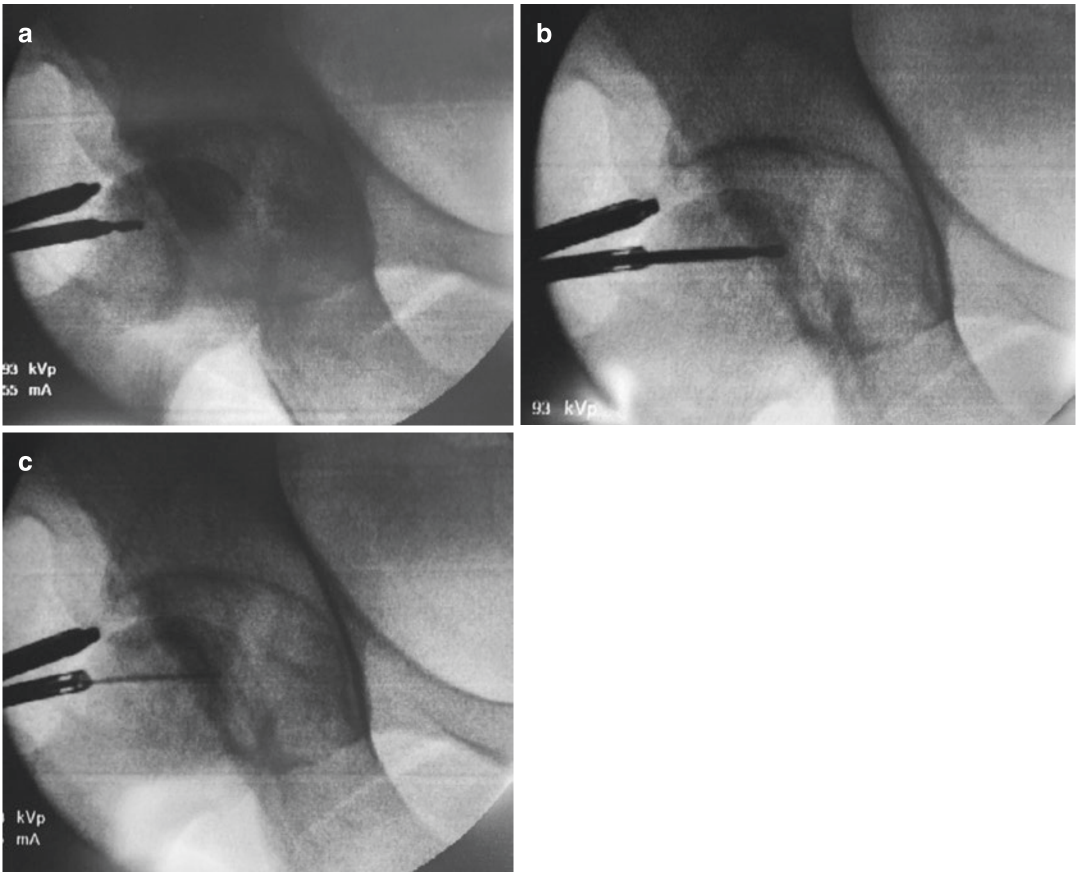

Fig. 9.2 (**a**, **b**) Arthroscopic-assisted head–neck junction core decompression from the peripheral compartment to the necrotic lesion. Intraoperative antero-posterior (AP) image intensifier view. (**c**) Nitinol guidewire inserted in the femoral head (FH) via the drilling track. The firm bony end point confirms that we have not penetrated the FH cartilage

posterior with the hip in extension and internal rotation. With this technique, we advocate multiple drilling with a small diameter drill (2–3 mm) to create more than one core track. This way CD is achieved and we minimize the risk of subchondral collapse that could be caused by a larger drill, since the entry and direction of the drilling is close and parallel to the FH surface (Fig. 9.2b). The thin hip arthroscopy nitinol guidewire can be inserted in the FH via the drilling track verifying by the sense of a firm bony end point that we have not penetrated the cartilage during the decompression (Fig. 9.2c).

Multiple drilling CD has achieved favorable outcomes while having lower complication rates, including a subtrochanteric fracture [22, 23]. A recent study compared standard core decompression and multiple drilling in a cohort of patients with sickle cell disease, finding no statistical significance in outcomes or complications [24].

Conversely, joint effusion, secondary to ON-related synovitis, is seen in up to 72% of cases regardless of articular collapse [25]. It is the author’s opinion that an arthroscopic joint washout and synovectomy can be of clinical benefit, since it reduces pain and joint effusion, improves range of motion, and by reducing the capsular stress from the effusion possibly improves the blood flow to the femoral head [16].

Following CD and through the path of the drill, the preferred supplemental biological material can be placed in the lesion.

9.5 Cell-Based Treatments of ONFH

Most of the theories regarding the mechanism of spontaneous ONFH point toward alterations in intravascular blood flow, leading to decreased oxygenation, toxicity, and cellular death. There are several recognized conditions and environmental insults that predispose patients to ONFH, such as high-dose corticosteroid administration, alcohol abuse, hemoglobinopathy, Gaucher disease, and coagulopathies [1, 13, 21, 26].

In ONFH, the decreased population and altered function of the mononuclear stem cells (MSCs) may influence the two different events in the pathogenesis of ONFH: the actual occurrence of ONFH itself and the bone repair process that follows. Accepting the premise that an important part of the underlying pathology in ONFH is cell deficiency, the next rational step is to consider the use of cell-based treatments to enhance the regeneration of lost or damaged bone.

Although clinical experience has shown that dead bone may be replaced by living bone, the osteogenic potential for repair in ONFH is low. A decrease in osteogenic stem cells in the femoral head has been observed beneath the necrotic lesion up to the intertrochanteric region, which might account for the insufficient creeping substitution in bone remodeling of the femoral head after ON. This can explain the fact that although reconstruction and repair have been observed after CD, it is usually slow and inadequate [27, 28].

Even though MSCs act via not-completely understood multifaceted pathways, it seems that they perform two separate functions that can influence the natural history of ON: (1) secretion of a wide spectrum of factors with anti-inflammatory, antiapoptotic, proangiogenic, proliferative or chemo-attractive, capacities, and (2) initiating the differentiation process for functional tissue restoration [29]. In clinical practice, a common source for MSCs is bone marrow mononuclear cells (BMMCs) due to their ease of harvest (iliac crest or femoral condyles), their abundance, and their marked osteogenic properties [29–32]. Tracking studies of BMMCs implanted directly into the necrotic area in ONFH showed 56% of installed cells remained in the implantation site 24 h after implantation. Similar studies in animal models also demonstrated the survival and multiplications of these cells up to 12 weeks postimplantation [33–35].

9.6 The Harvesting Technique of the Cellular Population

The most common site to collect bone marrow is either the anterior or posterior part of the iliac crest depending on the patient positioning and surgeon preference (Fig. 9.3a). Collection of bone marrow from the iliac crest can be accomplished by the use of a single beveled aspirating needle. A number of such systems are available commercially. The highest quality of bone marrow aspiration (number of stem/progenitor cells)

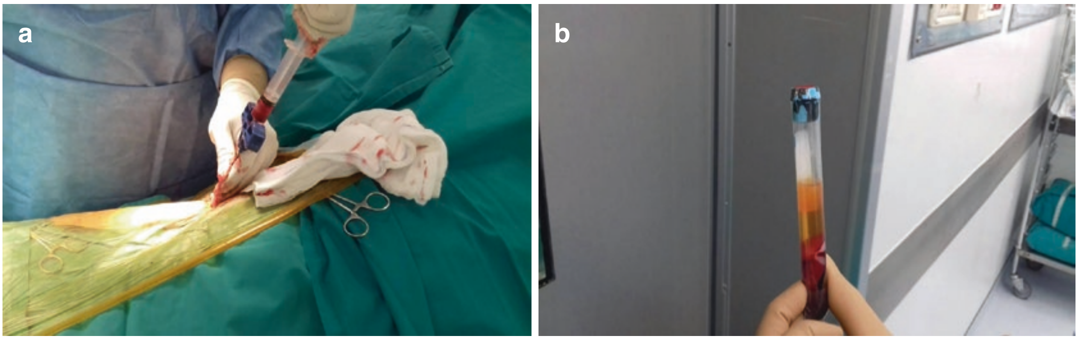

Fig. 9.3 (**a**) Bone marrow aspiration from antero-superior iliac spine (ASIS). (**b**) The aspirate following centrifuge; note the distinct cell separation

is when the aspirate is in small volumes (1–2 mL) and from different locations since, when a greater volume is drawn from any single area the peripheral blood infiltrates and dilutes the aspirate [36]. Technically, in order to achieve this, the needle is turned during successive aspirations thereby affording access to the largest possible space. After one full turn, the needle is slowly moved toward the surface and the process is repeated. The pooled aspirates (the volume can range between 30 and 120 mL) is filtered to separate cellular aggregates and fat (Fig. 9.3b). The aspirated material should be reduced in volume in order to increase the stem cell concentration. This is done with centrifugation, which separates the red blood cells (nonnucleated cells) and plasma in such a way as to retain only the nucleated cells: mononuclear stem cells, monocytes, and lymphocytes. After removing the nonnucleated cells, the aspirate is reduced to a concentrated myeloid suspension of stem cells that can be used for reinjection.

9.7 Arthroscopic Intraosseous Application of the Cellular Population

The procedure is performed at the time of CD. Following the drilling, the thin hip arthroscopy nitinol guidewire can be inserted in the femoral head following the CD track and then, over it, the cannulated arthroscopic needle. This ensures that the drill track is followed and the injected MSCs in the necrotic lesion is accurately placed. Backflow of the injected medium is not observed since the fluid diffuses to surrounding cancellous bone of the femoral head. During the injection time, the pressure in the femoral head can rise, but a normal pressure pattern is restored once the injection is finished [29]. Anecdotally, if excision of the cam deformity is done in conjunction with the CD drilling, overflow of the injected fluid can be observed from the exposed cancellous bone of the osteoplasty site after the injection of the first 10–15 mL, allowing the osteoplasty to act as a release “valve” to the increased pressure [21].

9.8 Conclusions

In summary, there is enough published clinical evidence to support hip arthroscopy as a safe and reliable adjunct in the management of osteonecrosis of the femoral head. It can be of value assessing the joint, and also addressing mechanical pathology commonly found in these hips. It can also help in a more technical manner by assisting the proper placement of the drill during retrograde or head–neck junction CD. But, since an important part of the underlying pathology in ON is cell deficiency, it is rational to consider the use of cell-based treatments to potentially regenerate lost or damaged bone. Cell therapies, particularly when employed at early stages of ONFH, improve clinical results and the survivorship of the native hip, reducing the need for hip replacement. The debate still remains on the ideal source, the lack of standardization and optimization of the harvested cells, their processing, method of transplantation, and even method of surgical delivery. The abundance of different cell-based treatments and our ability to control the behavior of the cells after implantation naturally raises some concerns on their long-term safety. None of the studies reported any major adverse events, but the quality of the evidence remains inadequate with long-term safety data still required [35].

It is the authors’ belief that in the era of minimally invasive techniques, the use of cell-based therapies constitutes good clinical practice since it is safe, involves minimal surgical time and difficulty, causes very little morbidity of the donor site, and potentially can influence only positively the outcome of CD. We agree with other published literature that there is enough evidence that cell therapy should not be considered experimental but rather a developing technique [37, 38].

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10 Fracture Treatment

Raul Zini and Manlio Panascì

10.1 Introduction

Hip traumatology is one of the fields for which arthroscopic treatment is most indicated. In severe hip trauma cases with fracture/dislocation, different sized articular loose bodies, starting from cotyloid rim or femoral head, may be left after luxation reduction; complete teres ligament lesions are always present and acetabular labral lesions can also occur; varying extent blunt lesions can occur against articular cartilage.

Arthroscopy allows a minimally invasive post-acute treatment with no need to expose articulation trough femoral head dislocation, thus minimizing the risks of open treatment.

However, the best advantage of a targeted arthroscopic treatment, providing joint fragments removal and articular sanctification, consists mainly in reducing risks of osteoarthritis evolution, which may occur if left untreated. The choice not to treat was very frequent until not long ago, supported by the belief that refraining from treatment was a lesser evil than a too aggressive and risky surgical approach.

According to literature [1], post-traumatic osteoarthritis risk is very high in luxation cases, with percentages varying between 24% and 54%, and it is strictly correlated to the present lesion's extent.

Predisposing factor of this constant osteoarthritis evolution is osteochondral fragments persistence within the joint that increases the production of the lytic enzymes in articular area, thanks to the presence of loose cartilage particles.

The reason why almost 24% of osteoarthritis evolution occurs in simple dislocations could be explained as due to the result of nonvisible articular microfragments. Katayama has asserted that computed tomography (CT) and magnetic resonance imaging (MRI) hip studies after simple traumatic dislocation may not detect cartilage fragments smaller than 5 mm. Mandell et al. [2] showed that 43.3% of patients who had a preoperative CT scan with negative findings for intra-articular fragments did show fragments at arthroscopy.

Therefore, these authors suggest arthroscopy to obtain a complete joint assessment and cleaning, providing a reduction in the potential risk of osteoarthritis evolution.

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10.1.1 Literature

There are not many studies in literature on the arthroscopic technique in hip traumatology, but all authors agree on its great avail. Keene and Villar in 1994 [3] were the first to highlight the avails of arthroscopic removal of loose bodies following traumatic hip dislocation. In 1996, Byrd [4] published three cases of young adults who underwent hip arthroscopy to remove posttraumatic loose fragments. In 2001, Kashiwagi [5] dealt with a case of bone fragment removal associated with teres ligament avulsion. Yamamoto in 2003 [6] highlighted the importance of arthroscopy in traumatology, reporting the first numerically relevant case study of 10 patients and 11 hips that underwent arthroscopic surgery; in 7 cases debridement of undiagnosed osteochondral small fragments was performed; in 2 cases larger fragments were removed; and in 2 cases a fragment synthesis with bio-reabsorbable pins was associated. Svoboda and Murphy in 2004 [7] suggested the importance of arthroscopy to remove fragments after posterior hip dislocation. Mullis in 2006 [8] showed a series of 36 patients with 39 operated hips: in 92% of cases loose bodies were removed; they were also found in 78% of cases that under X-ray and CT examinations seemed negative. Owens in 2006 [9] reported on 11 cases of articular fragments removal associated to statistically relevant labral lesions that showed no following problem or complication. Lansford in 2012 described two cases of arthroscopic fragment excision for Pipkin type I fracture [10]. Park et al. in 2014 described three cases of displaced fragment femoral head fractures treated by arthroscopic reduction and internal fixation [11]. In 2016, Kekatpure et al. reported the arthroscopic reduction and internal fixation of Pipkin type I femoral head fractures [12].

10.2 Indications

After posterior hip fracture/dislocation, articular osteochondral fragments may be present, either as cotyloid rim detached fragments or as femoral head ones.

Thompson–Epstein classification describes five types of pathological pictures of progressive importance: type 1 corresponds to simple traumatic dislocation without significant apparent fractures or with small detached fragments; type 2 describes a posterior cotyloid rim large fragment detachment; in type 3, there is a fracture with comminuted posterior cotyloid rim fragment; type 4 is fracture of the acetabular floor; and type 5 is fracture of femoral head.

Pipkin classification is a subclassification of the Thompson–Epstein type 5 fracture/dislocation. He describes four different types of increasing severity lesions: type 1 describes a femoral head osteochondral more or less bulky fragment, while types 2–4 describe more severe cases involving also femoral neck and acetabulum.

An arthroscopic treatment is provided to those patients showing, after dislocation reduction, joint loose fragments not significant enough to require osteosynthesis.

Thompson–Epstein type 3 (Figs. 10.1, 10.2, and 10.3) and Pipkin 1 (Figs. 10.4, 10.5, and 10.6) are the typical cases for which arthroscopic treatment is indicated. According to literature, indication might be extended also to Thompson–Epstein 1, given the possibility to find in articula-

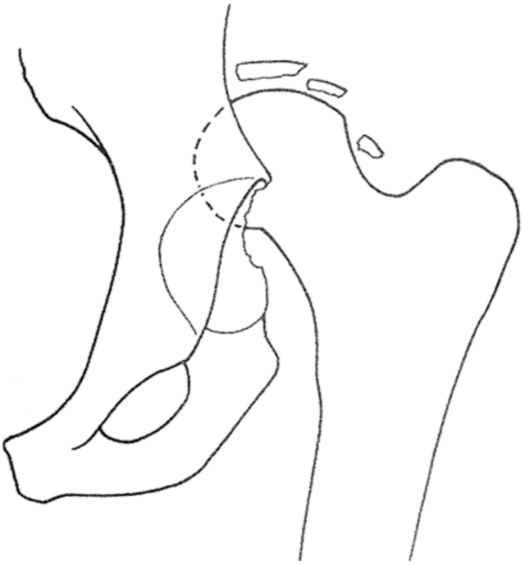

Fig. 10.1 Thompson–Epstein 3

Fig. 10.2 Thompson–Epstein 3 after reduction

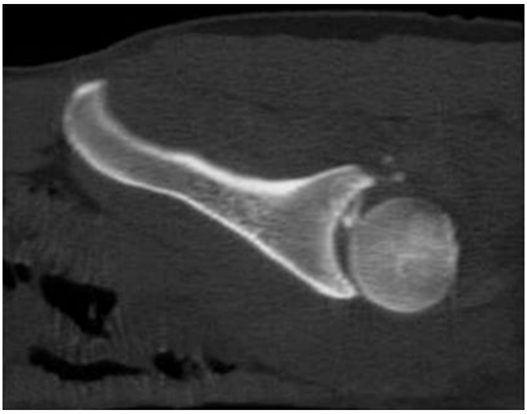

Fig. 10.3 Thompson–Epstein 3: computed tomography (CT) after reduction

tion minimal size fragments not detected either by standard X-ray or CT scan.

Indication must be however assessed only after a complete radiological evaluation; besides standard radiography exams and CT scan, a nuclear magnetic resonance (NMR), better determining cartilage conditions, may be useful to get complete assessments. Surgical time must take into account patient's conditions. Because a polytrauma is usually present, a complete general evaluation is mandatory as well as some days to recover from the post-traumatic critical phase. They are usually young patients who rapidly recover; surgery is therefore scheduled within the first week after trauma, once general conditions are improved and stabilized. In particular cases indication assessment can be postponed a few weeks, for getting the same therapeutical benefits.

Fig. 10.4 Pipkin 1

Fig. 10.5 Pipkin 1

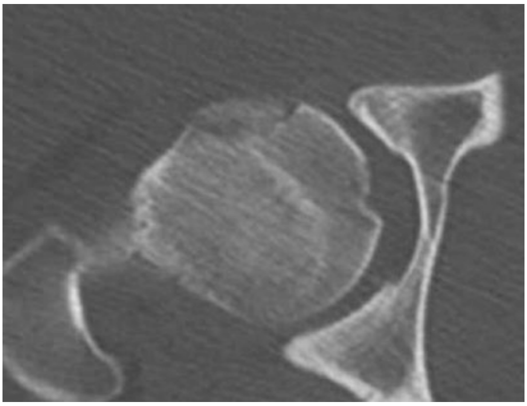

Fig. 10.6 Pipkin 1: computed tomography (CT) after reduction

10.3 Arthroscopic Technique

Arthroscopy is performed in supine position on traction table. Traction, as already described, has to be gradually exerted, constantly checking articulation with brilliance amplifier, to provide as little capsular stress as possible.

Instruments set is the one usually used in all hip arthroscopy; the use of a 70° scope is advised since it allows a wider and more panoramic articular vision; the use of an arthro-pump set on around 40–50 mmHg pressure value is advisable, to avoid the risk of a fluid extravasation; it is necessary to have available different sized graspers and one wide jaw loose bodies grasper, given the frequent presence of bulky fragments (Fig. 10.7).

Arthroscopic technique is a three-portal one: anterolateral, anterior, and posterolateral. This allows to explore the whole articulation and reach with the instruments all the areas where loose fragments might have adhered to.

Once portals are positioned, the hematoma is drained out; a proper lavage is performed and radiofrequency probes at capsular and synovial level achieve hemostasis. Once a good articular visualization is obtained, a diagnostic examination of articulation is performed; the presence of fragments at pulvinar (Fig. 10.8) level, more or less adhered to synovial tissue, is usually observed. Fragments are detached from cotyloid posterior rim where fracture has occurred, superficially extending to the acetabulum fossa (Fig. 10.9).

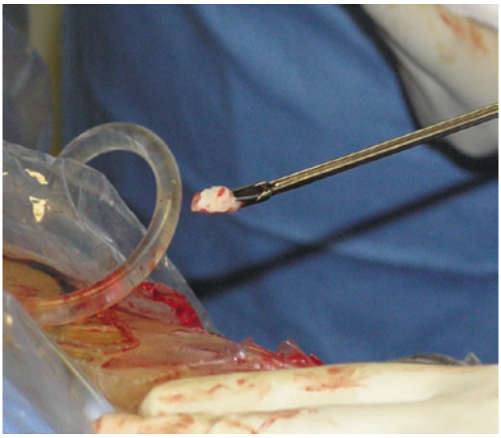

Fig. 10.7 Lose fragment removal

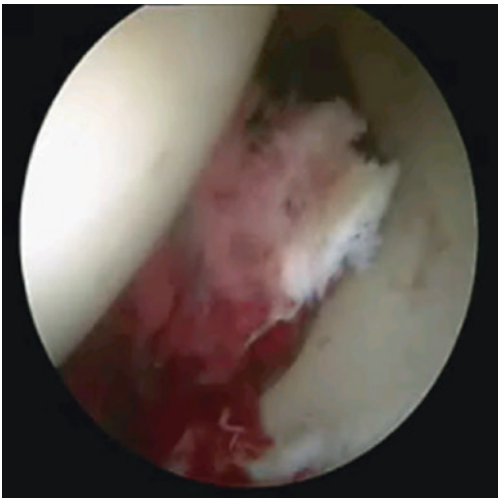

Fig. 10.8 Fovea capitis fragment

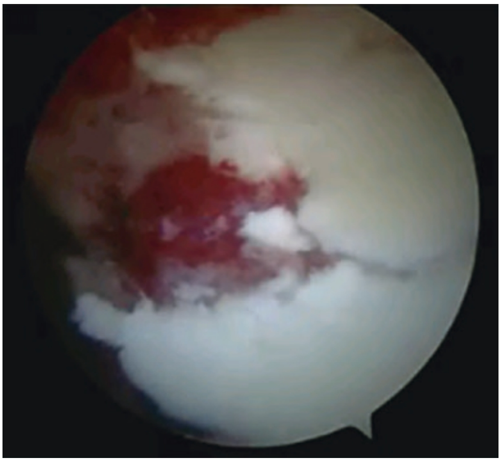

Fig. 10.9 Posterior fracture of the acetabulum

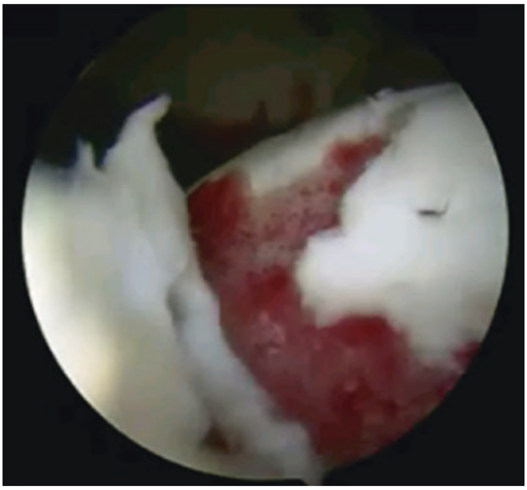

Fig. 10.10 Pipkin 1 with osteochondral femoral head defect

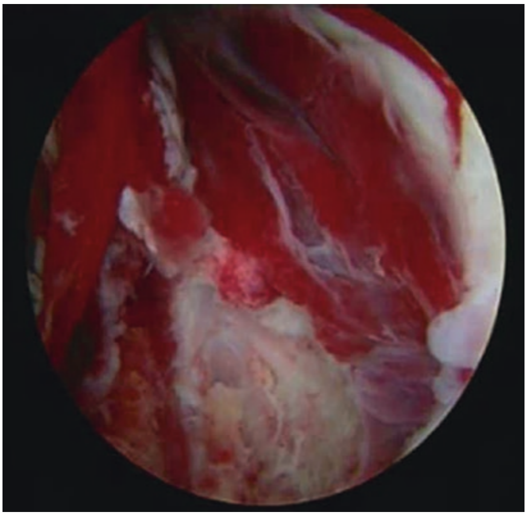

Fig. 10.11 Torn teres ligament

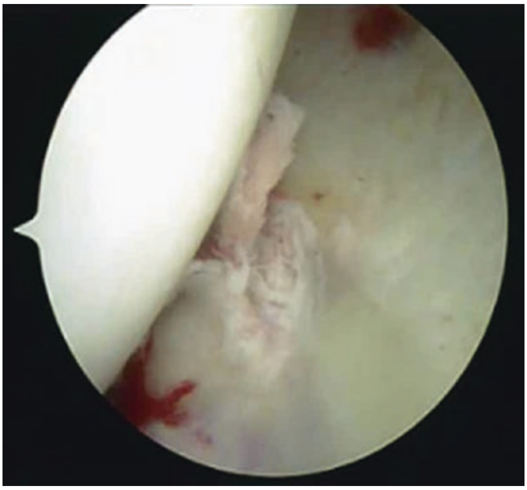

Fig. 10.12 Labral tear

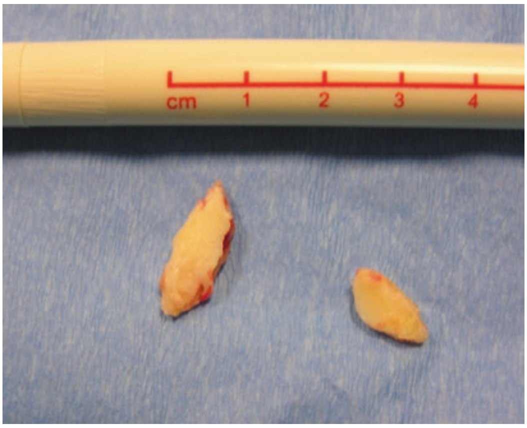

Fig. 10.13 Excised fragments

Below the fracture a more or less large capsular tear is found; it is always essential to explore femoral head (Fig. 10.10) since here, cartilage contusion areas can be noted besides small cartilage tears. A pre-operatory MRI can help to seek for possible impact-related chondropathies, which require careful exploration and palpation; it is also necessary to evaluate the teres ligament, which is always torn and often hemorrhagic and increased in volume (Fig. 10.11). Ultimately, acetabular labrum has to be evaluated since it frequently appears torn or detached (Fig. 10.12).

Once a complete articular evaluation has been achieved, the surgery phase can start. Portal switching helps to provide a better treatment of the single lesions by reaching them from different sides; loose bodies (Fig. 10.13) are removed with special graspers, usually from the anterior portal; it is always necessary to extend capsular incision and often the cutaneous one in order to remove fragments without difficulty; if detached, fragment is too bulky and risks to be lost in subcutaneous tissue during removal if frequent, so it is advisable to split it and remove its parts. More inferior fragments can be removed through postero-lateral portal; once articulation is freed from fragments, teres ligament is treated by removing torn parts; it is advisable to perform this surgery using flexible radiofrequency devices to avoid bleeding and subsequent hematoma; at the end any present labral lesion is trimmed; fractured cotyloid rim is also trimmed in order to avoid any following detachment of small fragments.

10.4 Complications

There is no particular risk of complications with arthroscopy in hip traumatology, even if it is necessary to take special care of patients usually showing complex associated comorbidities.

Surgery is preferably performed under selective subarachnoid anesthesia, and given patients clinical conditions it would be better, if possible, to perform it fairly rapidly to avoid further complications.

Traction can be less than the average since capsular tear following dislocation makes articulation more distractable. Besides, the presence of a torn capsule can be a disadvantage since it promotes distension fluid extravasation. In difficult cases with longer than average surgery time, this scenario may cause very severe problems. In literature, Bartlett [13] described one case of severe fluid intra-abdominal extravasation resulting in patient cardiac arrest; this occurred during arthroscopic surgery performed to remove an articular fragment following a very long osteosynthesis open surgery.

Severe complications, like the one described, are very rare, if not unique, while less severe complications can be more frequent but nevertheless important. An excessive traction can in fact determine sciatic nerve neurapraxia and an excessive inguinal compression can produce pudendal nerve neurapraxia.

10.5 Case Study and Results

Thirty-three patients underwent arthroscopic surgery between 2000 and 2017. Most of them (21) were treated between 2000 and 2017; number of cases progressively reduced in percentage after starting private practice in a clinic with no first aid. Population was 25 males and 8 females. Minimum age was 14 years and maximum 54 with an average of 25. Right side in 17 cases and left in 16. Average elapsed time between trauma and surgery was 6 days, with a minimum of 3 days and maximum of 21; 26 cases were treated within 10 days from trauma. Twenty-eight cases were classified as Thompson–Epstein 3, 5 cases as Pipkin 1. In 28 cases, acetabular osteochondral fragments were removed; in 5 cases, osteochondral fragments of femoral head were removed; in 4 cases, fragments from both sites were present; in 8 cases, osteochondral fragments included in the lesion with avulsion of teres ligament were present; in 12 cases, small fragments detached from acetabular rim together with a labral fragment were present. Neither arthroscopies without CT diagnosis of loose body (Fig. 10.14) nor reabsorbable pins synthesis of bulkier fragments have ever been performed. Results were brilliant and obtained in a short time with fast

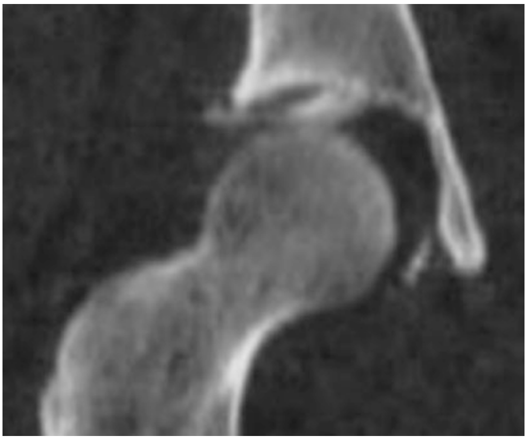

Fig. 10.14 Loose fragments at computed tomography (CT) scan

functional recovery of articulation and early rehabilitation. All patients were rechecked with an average follow-up of 4 years confirming the good initial results. Harris hip score (HHS) was good in 30 of 33 hips, with a mean HHS of 97 points (81–100).

Tip and Tricks

Fluoroscopy is useful to check capsular laxity (progressive traction)
Perform intracapsular hematoma aspiration to improve visualization
Only perform interportal capsulotomy to avoid capsular instability (capsulorrhaphy is advisable)
Address lateral retinacular vessels when possible to confirm bloody supply
Arthroscopic cannula may help fragments removal
Perform dynamic evaluation to confirm articular decompression

10.6 Conclusions

Traumatology can be considered a field of great interest for arthroscopic surgery. Indications are relatively frequent, mainly clinical and radiological, even if an adequate case selection is required.

Acute arthroscopic treatment of posterior hip fractures/dislocations gives great advantages compared to traditional arthrotomic techniques and provides a fast functional recovery and immediate rehabilitation. Arthroscopic option allows also to treat all those cases that were left untreated in the past, thus avoiding the risk of more severe postsurgical problems. Posttraumatic, osteochondral fragments removal drastically reduces the risk of posttraumatic coxarthrosis, which is, considering the very young average age of patients, an occurrence statistically frequent.

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11 Open Periacetabular Osteotomy

Kjeld Søballe

Until the early 1980s several reorienting triple or spherical acetabular osteotomies for treatment of hip dysplasia had been introduced [1–3]. None of these techniques gained popularity as the obvious joint-preserving treatment in young adults with hip dysplasia. In 1983, a group led by Professor Reinhold Ganz from Bern, Switzerland, started the development of a new periacetabular osteotomy for the treatment of hip dysplasia [4]. This technique has become the joint-preserving treatment of choice in young adults with symptomatic hip dysplasia [5–15]. It is often referred to as the "Bernese" or "Ganz" periacetabular osteotomy. This chapter describes a new minimally invasive approach for periacetabular osteotomy (PAO) developed by the senior author (K.S.).

11.1 The Periacetabular Osteotomy

In the periacetabular osteotomy, the acetabulum is reoriented to improve the coverage of the femoral head and the aim is to achieve congruity, stabilize the hip joint, medialize the hip joint center, and reduce contact pressures [4, 11, 16, 17] (Fig. 11.1). This will relieve pain, improve function and is likely to prevent further overload of the labrum, cartilage, and soft tissues, thereby delaying or preventing the development of osteoarthritis [5, 6, 8, 10, 12, 13]. As outlined by Ganz

Fig. 11.1 Part of an anteroposterior pelvic radiograph showing the right hip following periacetabular osteotomy

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et al. [4], the periacetabular osteotomy has several technical advantages compared to existing techniques: The posterior column remains intact leaving the pelvis stable, allowing partial weight bearing immediately postoperative and minimal internal fixation; extensive three-dimensional mobilization of the acetabular fragment is possible; the blood supply of the acetabulum is unaffected; and the dimensions of the true pelvis are maintained. In general, the periacetabular osteotomy is performed in patients after closure of the triradiate cartilage, but the exact indications for the periacetabular osteotomy may differ between institutions. For daily clinical practice, the following indications have been developed: (1) symptomatic acetabular dysplasia defined by persistent pain; (2) a Center-Edge angle of <25°; (3) a congruent hip joint; (4) maintained a range of motion with hip flexion of >110°; and (5) preoperative osteoarthritis corresponding to Tönnis grades 0–1.

11.2 Surgical Approaches and Technique

Since the development of the periacetabular osteotomy, several surgical approaches have been used. Most surgeons prefer the ilioinguinal or modified Smith–Petersen (iliofemoral) approaches [6, 12, 18–20]. The surgical techniques are shortly outlined in Appendix. These "classic" approaches inflict an extensive trauma to the tissues and some involve detachment of muscles, such as the rectus femoris and sartorius. The type of surgical approach may affect the occurrence of complications, duration of surgery, intraoperative blood loss, transfusion requirements, the ability of obtaining an optimal acetabular reorientation, and length of hospital stay [6, 20, 21]. The learning curve associated with the periacetabular osteotomy is well documented and technical and neurovascular complications have been reported by experienced surgeons [4, 8, 17, 20–22]. To improve outcome associated with the surgical approach, a new minimally invasive trans-sartorial approach for the periacetabular osteotomy was developed by the senior author.

11.3 Acetabular Reorientation

Achieving an optimal acetabular reorientation is a cornerstone of the periacetabular osteotomy. Under- or overcorrection of the acetabulum can cause symptoms such as the feeling of instability and impingement, respectively [9, 22, 23], and negatively influence the joint-preserving goals of the procedure [6, 13, 14]. The aim of the reorientation is to achieve an Acetabular Index angle between 0° and 10°, a Center Edge angle between 30° and 40°, and appropriate acetabular anteversion.

11.4 Outcomes of Surgery

Studies reporting the outcome of periacetabular osteotomy often represent heterogenic patient populations, in terms of diagnosis, severity of dysplasia, preoperative osteoarthritis, simultaneous surgical procedures, and duration of follow-up [5–8, 10–14, 18, 24–29]. The modified Smith–Petersen, ilioinguinal, and direct anterior approaches have been used [5–8, 10, 12–15, 18, 21, 24, 27]. Parameters such as duration of surgery, intraoperative blood loss, and transfusion requirements reflect the invasive characteristics of the periacetabular osteotomy (Table 11.1). Mean duration of surgeries is reported to be approximately 3–4½ h [6, 12, 14, 18, 21] and mean intraoperative blood losses are reported to be approximately 700–2300 mL [6, 8, 11, 12, 14, 18, 28]. One study reports a requirement of mean four portions of blood following all procedures [14]. Length of hospital stay is rarely reported; however, approximately 5–10 days of admission seems normal [12, 18, 28]. Moderate and severe neurovascular complications are most frequently reported to occur at a rate of approximately 0–5% using different surgical

Table 11.1 Summary of studies reporting duration of surgery, blood loss, transfusion requirements, or length of hospital stay

Author (year)	No. hips	Age mean (range)	Simultaneous femoral osteotomy no. hips	Surgical approach	Duration of surgery mean (range)	Blood loss mean (range)	Transfusion % of procedures no. port (range)	Length of hospital stay mean (range)
Siebenrock (1999) [14]	75	29.3 (13–56) years	16	Modified Smith–Petersen	3.5 h (2–5)	2000 mL (750–4500)	100% 4 port. (1–11 port.)	–
Trumble (1999) [6]	123	32.9 (14–54) years	33	56 modified Smith–Petersen 67 Ilioinguinal	4.5 h (–) 6.5 h (–)	800 mL (–) 1400 mL (–)	–	–
Matta (1999) [18]	66	33.6 (19–51) years	–	Modified Smith–Petersen	÷ fem. Osteo. 3.1 h (2–5) + fem. Osteo. 4.1 h (3.2–6)	939 mL (400–2000) 980 mL (500–1800)	–	7.9 (4–29) days
Davey (1999) [21]	70	36.5 (16–53) years	–	Modified Smith–Petersen	3.4 h (–)	–	–	–
Pogliacomi (2005) [12]	36	35* (15–55) years	0	4 modified Smith–Petersen 32 Ilioinguinal	3.3 h (1.8–7)	2300 mL (800–6900)	–	– (7–10)
Kralj (2005) [11]	26	34 (18–50) years	–	–	–	1400 mL (–)	–	–
Peters (2006) [8]	83	28 (25–47) years	14	Modified Smith–Petersen	–	715 mL (–)	–	–
Atwal (2008) [28]	122	23.6 (18–28) years	–	–	–	2191 mL (1200–4021)	–	5.3 (4–8) days

–: Parameter is not reported. *: Median years

approaches [4–8, 10, 12, 18, 25, 30]. The learning curve related to the occurrence of complications [4, 8, 17, 20, 21] affects the outcome in some studies. Based on this, the periacetabular osteotomy can, in classical terms, be considered and extensive surgical procedure with a risk of disabling complications.

In most studies the aim of the reorientation has been achieved when considering mean postoperative Center Edge and Acetabular Index angles [5, 10–13, 25, 27]. The short-term hip joint survival rates are in most studies >90%. Few studies report the medium- and long-term hip joint survival [11, 13, 14]. Recently, a hip joint survival rate of 60.5% has been reported at a mean follow-up of 20.4 years [13]. Clinical scores improve following periacetabular and there is evidence that significant improvements last up to 10 years [14]. A controversy in contemporary periacetabular osteotomy is whether arthrotomy and necessary labral intervention should be performed or not. There are no results of sufficient methodological value to support either approach.

11.5 Conservative Treatment?

Whereas many cases of asymptomatic mild and moderate hip dysplasia will not develop osteoarthritis in early decades [31], it remains unclear whether all symptomatic cases with persistent hip pain will. In the case of periacetabular osteotomy, this potentially could lead to the performance of unnecessary surgery in marginal cases. Conservative treatment might then be a treatment option, but selection criteria are unknown. However, when patients with persistent symptoms are referred, they often suffer moderate or severe pain, which affects daily living, and given the ability of the periacetabular osteotomy to relieve pain, improve function, and preserve the joint [5, 6, 8, 10, 12, 13], surgery is justified.

11.6 The Minimally Invasive Approach

Classically, the surgical treatment of hip dysplasia by means of the periacetabular osteotomy has been associated with extensive surgical approaches potentially inducing severe. This leaves room for advances in the surgical treatment. A safe surgical procedure with achievement of optimal acetabular reorientation is the surgical mainstay of a successful periacetabular osteotomy. To improve outcome associated with the surgical approach, a new minimally invasive trans-sartorial approach for the periacetabular osteotomy was developed by the senior author.

11.6.1 Surgical Technique of the Minimally Invasive Approach

The patient is placed on a radiolucent operating room table in the supine position. The placement of the drapes allows for full mobilization of the lower extremity on the operated side. Fluoroscopic evaluation is necessary throughout the operation and therefore the pelvis is kept in a neutral position in order to avoid excessive tilting or rotation. The fluoroscopy equipment is positioned to facilitate obtaining the anterior–posterior and 60° (false profile) views.

The skin incision begins at the anterior superior iliac spine and continues distally along the sartorius muscle. The length of incision is approximately 7 cm. The fascia is carefully incised, and the lateral femoral cutaneous nerve isolated and carefully retracted. To facilitate transverse retraction of the soft tissues, a semiflexed position of the hip joint is maintained during performance of the osteotomies. For this purpose a splint is used. A periosteal elevator is placed subperiosteally along the medial aspect of the ilium starting at the anterior superior iliac spine, and it is advanced until it lies just below the linea terminalis. The inguinal ligament is cut at the attachment to the anterior superior iliac spine allowing further mobilization of the soft tissues. The periosteal elevator is then pushed medially splitting the sartorius muscle in the direction of its fibers and the deep fascia of the muscle is cut. The periosteal elevator is then replaced with a blunt retractor positioned along the medial aspect of the ilium to retract the iliopsoas and the medial part of the split sartorius muscles medially. At this point the osteotomies are performed (Fig. 11.2). Time spent on the approach is approximately 5 min.

11.6.2 Performance of Osteotomies

11.6.2.1 General Surgical Principles

The acetabular index and center edge angles following reorientation should correspond as closely as possible to the normal anatomy (acetabular index angle: 0–10°; center edge angle: 30–40°). It is of equal importance that the surgeon obtains appropriate anteversion of the acetabulum. Assessment of range of motion and joint stability at the end of the procedure will help the surgeon evaluate the change in hip joint mechanics. This description of the minimally invasive approach

Fig. 11.2 A blunt retractor positioned along the medial aspect of the ilium to retract the iliopsoas and the medial part of the split sartorius muscles medially

will give the reader an understanding of soft tissue mobilization, instrument handling, and the performance of the osteotomies. The understanding of the anatomy and utilization of fluoroscopy during surgery are the keys to a safe, minimally invasive periacetabular osteotomy.

11.6.2.2 Pubic Osteotomy

Subperiosteal access to the superior ramus of the pubic bone is gained using a periosteal elevator. It is important that the pubic osteotomy is performed medially on the superior ramus since the bone otherwise is too thick making the osteotomy and mobilization difficult or impossible. A curved blunt retractor is placed in the obturator fossa behind the superior ramus of the pubic bone. It is important that this retractor be placed subperiosteally to protect the obturator artery and nerve. A splined retractor is then placed anteriorly and medially to the site of the osteotomy in order to retract the iliopsoas muscle medially and protect the iliac artery and vein and the femoral nerve (Fig. 11.3). The superior ramus is then osteotomized under direct visualization using a slightly curved osteotome. It is important to advance the osteotome until the osteotomy is complete otherwise the repositioning of the splined retractor becomes difficult as it will tend to slide into the osteotomy. The surgeon will often be able to hear and feel (loss of resistance) when the bone is fully osteotomized. This sensory input should be utilized during surgery to avoid both creating an insufficient osteotomy and advancing the osteotome into the soft tissue.

Fig. 11.3 The site of the osteotomy on the pubic bone and the placement of the instruments: a curved blunt retractor is placed behind the pubic bone to protect the obturator nerve and artery. A splined retractor is used for medial retraction of the soft tissues and a slightly curved osteotome is used to create the osteotomy

11.6.2.3 Ischial Osteotomy

When advancing to the ischial osteotomy, the splined retractor is kept in its position to retract the iliopsoas muscle medially. A large pair of scissors is used to penetrate the interval immediately lateral and distal to the pubic osteotomy, and the scissors are advanced to the ischium below the acetabulum. Keeping the scissors in place, a 30° angled osteotome can be placed on the ischium. The correct placement of the osteo-

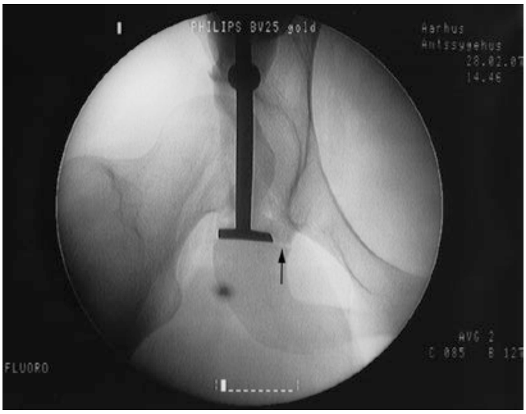

Fig. 11.4 The fluoroscopic anterior–posterior view showing the lateral placement of the osteotome at the ischial bone below the teardrop. The osteotomy performed at the medial edge of the ischium is seen (black arrow)

tome is verified using fluoroscopy (anterior–posterior view). The osteotomy begins approximately 5 mm distal to the radiographic teardrop. A 1.5 cm osteotomy is performed in two steps beginning at the medial edge and then moving the osteotome laterally before the next step (Fig. 11.4). A 30° angled osteotome is advanced along the inner aspect of the pelvis until it can be placed at the medial aspect of the ischium with one leg of the osteotome in the existing 1.5 cm osteotomy. The placement of the osteotome and the osteotomy itself are performed under strict fluoroscopy control utilizing the so-called false profile view that is angled 60° to the anterior–posterior view (Fig. 11.5). The ischium bone is then osteotomized from the medial to lateral aspect in a length equal to 2–3 widths of the osteotome (Fig. 11.6). This osteotomy tends to be slightly curved with the concavity towards the acetabulum. In order to advance in the same plane as the initial 1.5 cm of the osteotomy and to obtain an almost horizontal osteotomy, the handle of the 30° angled osteotome must be pushed medially. When the posterior aspect of the ischium is osteotomized, the sciatic nerve can be damaged if the osteotome is advanced too far past the bone in the lateral direction.

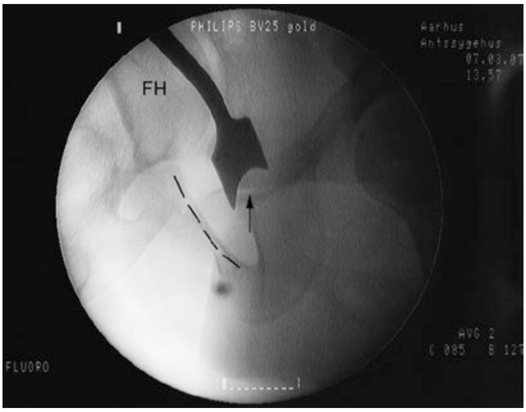

Fig. 11.5 The fluoroscopic false profile view angled 60° to the anterior–posterior view. Correct placement of the osteotome with one leg in the existing osteotomy (black arrow). The black dashed line marks the border of the pubic bone towards the obturator foramen. *FH* femoral head

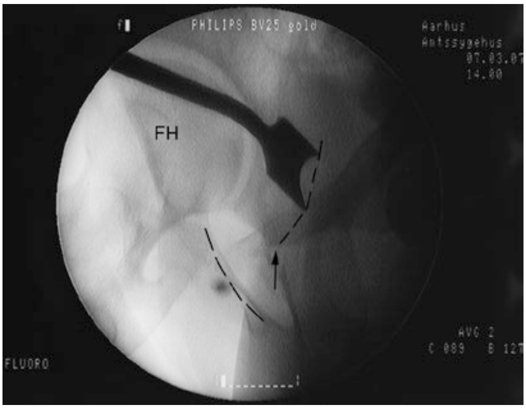

Fig. 11.6 Correct placement of the osteotome for the last step of the ischial osteotomy. As illustrated by the black dashed line, the osteotomy is slightly curved. The black arrow marks the level of the already performed first step of the osteotomy. The black dashed line to the right marks the border of the pubic bone towards the obturator foramen. *FH* femoral head

11.6.2.4 Iliac Osteotomy

Initially a Kirschner wire is inserted along the inner aspect of the pelvis approximately 3 cm cranial to the acetabulum. This is done to secure an appropriate distance away from the joint. From experience, we have found it easier to mobilize and control the acetabular fragment if this distance away from the joint is achieved. The first step of the iliac osteotomy begins between the anterior superior iliac spine and the anterior inferior iliac spine at the level of the Kirschner wire. It is performed using an oscillating saw stopping approximately 1 cm before reaching linea terminalis. In some patients the distance from the anterior superior iliac spine to the cranial limit of the joint is relatively short. In these cases, a small oblique osteotomy under the anterior superior iliac spine is recommended. To protect the structures lateral to the ilium, a blunt retractor is tunneled close to the bone along the outer aspect of the ilium in the area between the anterior superior and anterior inferior iliac spines. The blunt retractor must be advanced close to the bone as otherwise the blood supply from the superior gluteal artery can be damaged. A retractor protects the structures medial to the ilium. The first step of the osteotomy is then continued using a wide, straight osteotome. With an anterior open angle of approximately 120°, it is advanced behind the hip joint until it reaches the ischial osteotomy while the posterior column is maintained intact. Fluoroscopy must be used during this last step of the iliac osteotomy (60° angle, false profile view) (Fig. 11.7).

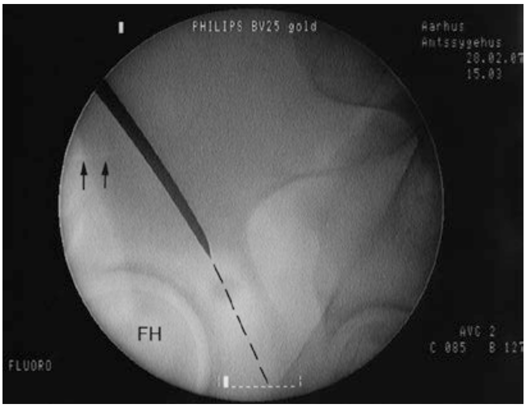

Fig. 11.7 The fluoroscopic false profile view angled 60° to the anterior–posterior view, showing the advancement of a straight osteotome in continuation with the first step of the iliac osteotomy (black arrows). It is advanced (black dashed line) at an anterior open angle of around 120° between the joint and the posterior column until it reaches the ischial osteotomy. *FH* femoral head

11.6.2.5 Reorientation

A Schanz screw with a handle is placed in the acetabular fragment 2 cm distal to the iliac osteotomy. The iliac and ischial osteotomies can in succession be retraced using a 30° angled osteotome to secure that there are no bony bridges or spikes left, interfering with mobilization of the acetabular fragment. The Schanz screw gives the surgeon full control of the fragment during the 3-D reorientation. The first step of the acetabular reorientation is to achieve sufficient lateral coverage. This is done by adducting the fragment. In our experience this maneuver is sufficient to medialize the hip joint center which in dysplastic hips often is lateralized. As a rule of thumb the acetabular index angle following reorientation should approximate 0° (horizontal positioning of the sclerotic acetabular roof) and never should be less as this will result in overcoverage and impingement. The second step of the acetabular reorientation is to achieve sufficient anterior coverage. This is done by extension of the fragment. In our experience very little movement is needed to create sufficient anterior coverage. The risk of too much anterior coverage and retroversion is great at this point in the reorientation procedure. Version of the acetabulum is evaluated using fluoroscopy of the entire pelvis in the anterior–posterior view by assessing the relationship between the anterior and posterior acetabular rim. Sufficient anteversion is achieved when the posterior rim is lateral to the anterior rim and the center of the femoral head and the anterior rim is medial to the center of the femoral head and there is no cross-over sign. If the acetabular fragment has been properly mobilized and reoriented, cranial displacement of the superior ramus and

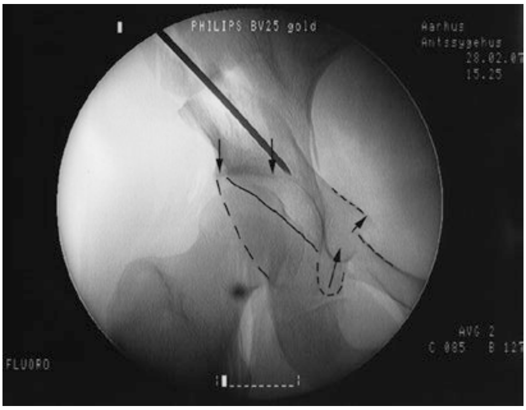

Fig. 11.8 A large threaded Kirschner wire is temporarily securing the position. Notice the horizontal positioning of the medial and lateral extents (arrows) of the sclerotic acetabular roof, the anteverted configuration of the acetabulum (posterior rim = dashed line; anterior rim = solid line), the cranial displacement of the superior ramus, and the cranial and medial displacement of the teardrop figure

cranial and medial displacement of the teardrop can be observed in the anterior–posterior fluoroscopic view. If these are not observed, the fragment is hinging probably due to an unfinished osteotomy of the ischium (Fig. 11.8). A large threaded Kirschner wire is then placed from the ilium into the acetabular fragment in order to temporarily secure the new position. Excessive tilt and rotation of the pelvis are avoided through the initial positioning of the patient. The acetabular version has to be addressed as described previously. Fine adjustments of the reorientation might be necessary. When no further adjustment is needed, two stainless steel screws are placed from the ilium at the anterior–superior iliac spine into the acetabular fragment to secure its position. The positions of the screws are visualized using fluoroscopy and the stability of the fixation is tested by applying force on the fragment. The hip range of motion is assessed, and by internally rotating the flexed hip, no impingement should be encountered. By flexing the hip and pushing the knee towards the operating room table, posterior stability of the joint is tested. After irrigation with saline, the inguinal ligament is reattached and the soft tissues are closed in layers. A suction drain is not used.

11.6.2.6 After Care

On the day following surgery the patient is mobilized walking on crutches with 30 kg of weight bearing on the operated side. Patients are allowed full range of motion. X-ray films are obtained postoperatively and after 8 weeks, and at that time the patient is allowed full weight bearing. Using this regimen, there is no risk of secondary displacement or nonunion [32]. The patient is discharged the day after surgery.

11.6.3 Outcome of Surgery

We have assessed the outcome of the minimally invasive approach in two studies [33, 34]. The aims of these two studies were (1) to assess if the new minimally invasive trans-sartorial approach for periacetabular osteotomy is safe, allow optimal acetabular reorientation, and minimize tissue trauma. The length of hospital stay, duration of surgery, intraoperative blood loss, hemoglobin reduction, transfusion requirements, hip joint survival, complications, and achieved acetabular reorientation were assessed; and (2) to assess whether the new minimally invasive approach produces an outcome similar to that of the "classic" ilioinguinal approach for the periacetabular osteotomy. The approaches were compared with respect to the outcome parameters mentioned earlier to explore if the results supported continued use of the minimally invasive approach. The results of the two studies are shown in Table 11.2.

Table 11.2 Summary of studies investigating the outcome of the minimally invasive approach for the periacetabular osteotomy

Author (year)	Approach	No. hips	Age	Duration of surgery	Blood loss	Hemoglobin reduction	Transfusion % of procedures no. port.	Length of hospital stay	Achieved CE and AI angles	Hip joint survival Kaplan-Meier estimates
Troelsen 2008 [33]	Minimally invasive	94	Mean 37 years	Mean 73 min	Median 250 mL	Mean 33 g/L	3% median 2 port.	Median 8 days	Median CE: 34° AI: 3°	98% at 4.3 years
Troelsen 2008 [34]	Minimally invasive Ilioinguinal	165 98	Median 35 years Median 31 years	Median 70 min Median 100 min	Median 250 mL Median 500 mL	Mean 32 g/L Mean 40 g/L	4%median 2 port. 18% median 2 port.	Median 7 days Median 9 days	Median CE: 33° AI: 2° Median CE: 31° AI: 9°	97% at 4.9 years 93% at 4.9 years

11.7 Conclusions

The periacetabular osteotomy is applied worldwide and is the joint-preserving treatment of choice in young adults with symptomatic hip dysplasia. The procedure has the potential to relieve pain, improve functions of daily living, and preserve hip joints by delaying or even preventing development of early osteoarthritis. The periacetabular osteotomy can be considered a major advance in the field of adult joint-preserving hip surgery. However, more reports on the medium- and long-term results are needed.

Further surgical advances have been achieved by the development of the minimally invasive approach for the periacetabular osteotomy. Using this approach, the periacetabular osteotomy can be performed safely, with optimal reorientation of the acetabulum and minimized tissue trauma. Duration of surgery, blood loss, and transfusion requirements are all at a very low level and the short-term hip joint survival is encouraging.

Appendix

Short outline of the surgical techniques for the modified Smith–Petersen and ilioinguinal approaches as they were performed at our institution:

Specific modifications of the Smith–Petersen approach has been reported [20]. The skin incision was made along the anterior third of the iliac crest to the anterior superior iliac spine where it curved distally and continued vertically along the tensor fasciae latae for approximately 10 cm. The internervous planes between the tensor fasciae latae and sartorius, and the gluteus medius and rectus femoris were developed. In contrast to the previously described modification of the Smith–Petersen approach, the rectus femoris was not detached. In some of the first cases the origin of the sartorius muscle was detached by means of an osteotomy.

The ilioinguinal approach was performed as previously described [35], but without lateral extension along the iliac crest. The skin incision extended from the anterior superior iliac spine, along the inguinal ligament, and terminated at the level of the pubic symphysis near the midline. The inguinal ligament was incised leaving the origins of the abdominal musculature and fascia attached to the proximal part of the split ligament. Further access was created by incising the iliopectineal fascia that separates the lacuna musculorum and lacuna vasorum. This allowed mobilization of the iliopsoas muscle that, combined with medial retraction of the external iliac vessels, created access to performance of the osteotomies through two windows: one medially and one laterally to the iliopsoas muscle.

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Reverse Periacetabular Osteotomy

12

Michael Wettstein

12.1 Introduction

Besides a normal cervicocephalic offset, a correct three-dimensional (3D) orientation of the acetabulum is essential to achieve normal hip joint motion. Among possible deformations, retroversion is a malorientation of the socket leading to more or less posterior instead of anterior opening [1]. This results in an abnormal contact between the femoral neck and the acetabular rim, known as femoroacetabular impingement (FAI), in this case of pincer-type [2]. FAI leads to inguinal pain, decreased motion in flexion and internal rotation, and, finally, osteoarthritis of the hip [2].

The easiest treatment option consists in trimming of the prominent anterior wall [3]. In the setting of true acetabular retroversion, this however decreases the size of the articular surface and results in an iatrogenic dysplasia. Therefore, reorientation by the means of a reverse periacetabular osteotomy (PAO) is the treatment of choice in this situation [4, 5].

12.2 Definition of Acetabular Retroversion

Among etiologies for pincer impingement, focal acetabular overcoverage, coxa profunda or protrusion, and acetabular retroversion have been described [2]. It is of paramount importance to distinguish between these entities, as the treatment is based on the anatomic shape of the acetabulum.

The diagnosis of acetabular retroversion is based on the correlation between clinical and radiographic findings: Typically, patients will complain about anterior groin pain with a decreased flexion and internal rotation [5]. The anterior impingement test reproduces the patient's inguinal pain [6].

Conventional imaging is based on an anteroposterior (ap) pelvic radiograph, centered on the symphysis pubis and with strict control of inclination and rotation, as these parameters may change the projected orientation of the acetabulum, increasing or decreasing the version, and thus leading to a wrong diagnosis [7]. If in doubt about the correct projection, an analysis with a dedicated program, allowing to reorient the pelvis, might be used [8].

On the correctly centered ap-view, the relative position of the acetabular walls needs to be evaluated. A normal shape is defined as the anterior wall projecting medially of the posterior wall, both meeting at the level of the roof at a sharp angle (Fig. 12.1a). If the anterior crosses the posterior wall (positive cross-over sign), the amount

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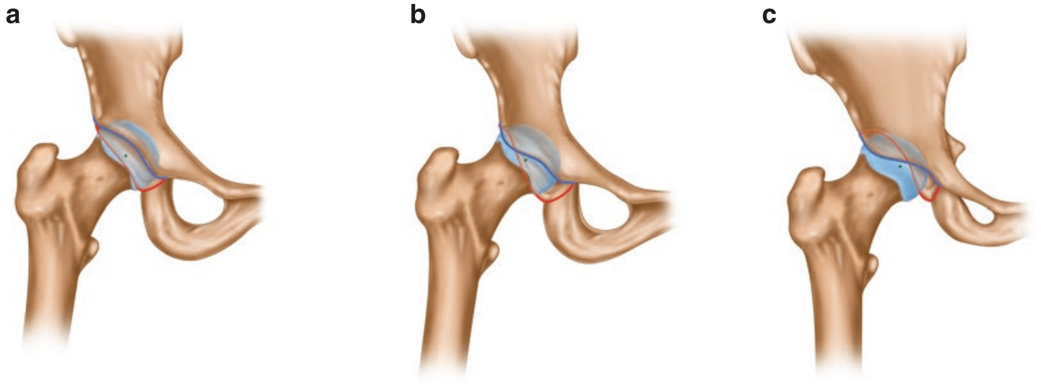

Fig. 12.1 (**a**) Normal acetabulum with anterior and posterior wall meeting at sourcil with a sharp angle. Head center medial projects medially of posterior wall. Ischiatic spine not visible. (**b**) Overcovering with positive cross-over, but head center still projects medially of posterior wall and ischiatic spine is not visible. (**c**) Retroversion. Positive cross-over with head center lateral of posterior wall and ischiatic spine visible. Furthermore, the retroversion index is higher than 30%, the convergence angle of the walls at the sourcil much flatter, and the iliac wing much larger with a laterally prominent anteroinferior iliac spine (AIIS) and a narrow obturator foramen

of crossing must be assessed, using the retroversion index. This index indicates the ratio of posterior wall covered by the anterior wall. If the index is lower than 30%, this represents a focal overcoverage (Fig. 12.1b). If the index is higher than 30%, there is a high risk of real retroversion of the acetabulum. In this case, further signs are found, with a positive posterior wall sign (posterior wall medial to the center of the femoral head) and positive ischiatic spine sign (spine visible medially of the ilio-pubic line), which are typical for acetabular retroversion (Fig. 12.1c) [5, 9–11]. Rarely, extreme cases of complete acetabular retroversion can be found with the anterior wall completely covering the posterior wall. These cases may be misleading, but can be diagnosed by a flatter convergence angle of both walls at the lateral roof.

The prevalence of isolated retroversion was described as 5% [12].

As additional diagnostic criteria, a much larger iliac wing, a very prominent anteroinferior iliac spine (AIIS), and a narrow obturator foramen have been described as consequences of a global external rotation of the hemipelvis [13, 14].

The lateral coverage of the head must always be evaluated, as a significant number (17–37%) of dysplastic hips can also be retroverted [15–17]. Fuji et al. showed that retroversion associated to dysplasia induces earlier appearance of symptoms than in lateral or anterior dysplasia, whatever the degree of dysplasia [18]. This can be explained by the increased degree of posterior wall hypoplasia in these cases.

As a decreased cervicocephalic offset (cam deformity) can be found simultaneously in a significant number of cases, this must also be evaluated on the conventional radiographs [2]. Classically, an axial view of the femur (cross-table, Dunn, Lauenstein, etc.) is made to see the anterior cervicocephalic junction. However, the ap pelvic view shows the lateral offset and, in convergence with the sagging-rope sign described in Legg-Calvé-Perthes disease, also the anterior offset (Fig. 12.2) [19]. Using this sign, I did not do any axial view for years, as I found a good correlation between this sign and the morphology found on radial magnetic resonance arthrography (MRA) sequences [NP].

The second radiograph is a false-profile view, as described by Lequesne [20]. This allows to analyze the morphology of the anteroinferior iliac spine (AIIS) and the joint space. Specifically, early joint space narrowing would be seen on the false-profile view rather than on the ap-view, either in an anterosuperior location in cam impingement, or posteroinferior in pincer

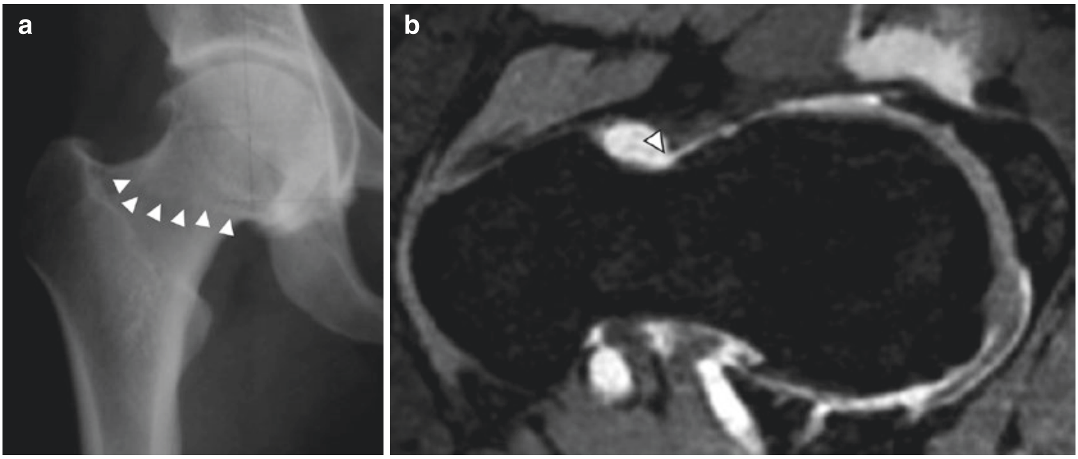

Fig. 12.2 (**a**) Anteroposterior (ap)-view of a right hip showing the sagging-rope sign, marked with arrowheads, which marks the lateral border of the femoral head, showing a decreased anterior offset. (**b**) Radial arthro-MRI sequence of the same patient, confirming the lateral position of the head–neck junction corresponding to the sagging-rope sign

impingement. This allows for a more precise conventional evaluation of the cartilage, any significant narrowing of the joint space or displacement of the head (subluxation with positive crescent sign) being a sign of a significant lesion of the cartilage, which contraindicates conservative surgery [21].

Further evaluation of the labrum and the cartilage needs a magnetic resonance arthrography (MRA). The gold standard is to obtain radial sequences and distraction images to improve the 3D visualization of bone morphology and the discrimination of chondro-labral lesions [22, 23]. Additional images of the distal femur can be obtained to measure femoral antetorsion, which recently gained increasing interest in the setting of FAI [24].

Computerized tomography (CT) imaging may be used to evaluate the 3D morphology of the acetabulum or femoral antetorsion, but is rarely used by the author as the above-mentioned imaging modalities supply all the necessary information. Based on local habits, CT-arthrography may be used instead of magnetic resonance imaging (MRI) to evaluate the chondro-labral complex.

The term “retroversion” is frequently misused in the literature in the context of a positive cross-over sign. To avoid misleading concepts and inadequate treatments, I suggest to adhere to the above-mentioned definition of true retroversion and to use the term retroversion only in this situation. Other situations with a positive cross-over sign correspond to a focal overcoverage.

12.3 Indications and Contraindications

Steppacher et al. showed that the lunate surface in retroverted acetabula is of the same size as a normal acetabulum [4]. This means that the anterior wall is not oversized nor the posterior wall undersized, which could however be the case in dysplasia, but they are malpositioned.

Any trimming of the anterior wall in this situation decreases the size of the joint surface, leading to an iatrogenic dysplasia and possible instability of the joint. This treatment is the first choice in cases with a retroversion index lower than 30% and a negative posterior wall and ischiatic spine sign, corresponding to focal overcoverage. In cases with significant anterior cartilage lesions, where a reverse PAO would turn these lesions into the weight-bearing zone, a partial rim trimming with offset correction could be considered as palliative treatment in young patients. This can be realized either by arthroscopy or by surgical hip dislocation (SHD), depending on the situation.

In true retroversion, the treatment of choice is to correct the orientation of the acetabulum with a reverse PAO. This treatment has been proposed for patients younger than 40 years, but encouraging results were also found in older dysplastic patients [25]. I therefore consider that the health of cartilage is a more significant indicator than chronological age. Of course, the importance of such an operation has to be weighed-out in every single situation compared to patient age, cartilage state, and possible outcome, as well as discussed with the patient.

Osteoarthritis Tönnis grade higher than 1, significant cartilage lesions on arthro-MRI, or subluxation of the head on the false-profile view should be considered as contraindications for conservative surgery.

As a cam deformity is frequently associated, and must be diagnosed based on the preoperative imaging, testing of hip motion in flexion and internal rotation is mandatory after correction of the acetabular orientation [26]. If 30° of internal rotation are not achieved in 90° of flexion, I consider that an arthrotomy must be done for offset correction to avoid any residual impingement. Even if actual results about concomitant treatment of the cam deformity during PAO are controversial, the risk of further cartilage lesions and the necessity of a potential second operation outweigh the additional time necessary for an arthrotomy [27–30].

If a significant torsional problem was diagnosed before (normal femoral torsion is considered between 5° and 25°, ideal at 15–20°), a femoral rotation osteotomy should be performed simultaneously to avoid residual instability or impingement problems [24, 31].

12.4 Patient Positioning and Incision

Basically, the surgical technique regarding approach and osteotomies does not differ from standard PAO [32].

The patient is positioned on a radiolucent table under general anesthesia with full muscle relaxation. Sterile draping of the operated leg is necessary, as it must be freely mobile during the procedure. A cell-saver device as well as tranexamic acid are used as routine because of the potential risk of bleeding and to decrease the transfusion requirements [33, 34].

12.5 Surgical Approach

Initially, the modified Smith-Peterson approach was used, then modified to a more minimal invasive approach with a short vertical incision, as proposed by Lara et al. [35]. Actually, a low ilioinguinal-type or bikini incision is favored, because of its better cosmetic results and easier exposure of the pubic ramus. The incision is parallel to and approximately 2 cm below the iliac crest, the medial part being oriented more downwards to facilitate later access to the joint (Fig. 12.3). Medially of the tensor fasciae latae, care must be taken to avoid the lateral femoral cutaneous nerve (LFCN), by not dissecting the subcutaneous fat over the sartorius.

The fascia of the tensor is incised longitudinally, approximately 2 cm from of the medial border, and the muscle belly retracted laterally inside the fascial sheath, which further protects the LFCN (Fig. 12.4). After 30° of flexion of the hip, using a leg holder that will be kept in place during the whole surgery to decrease muscle tension, the deep innominate fascia is incised longitudinally to

Fig. 12.3 Modified inguinal or bikini incision, parallel to the iliac crest. Pincette points to the anterosuperior iliac spine (ASIS). To decrease skin tension, the superficial incision goes 2–3 cm more medial than the medial border of the tensor fasciae latae

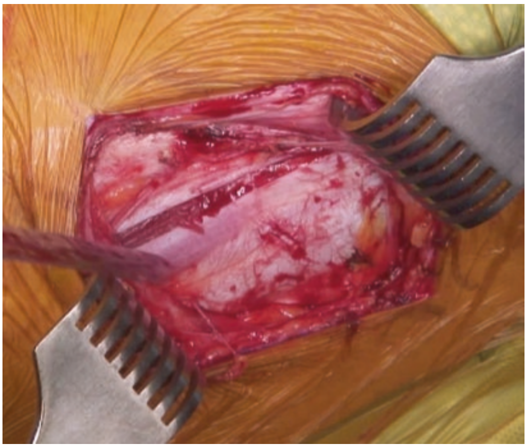

Fig. 12.4 Incision of fascia tensor fasciae latae over the muscle to keep a safe distance with the lateral femorocutaneous nerve

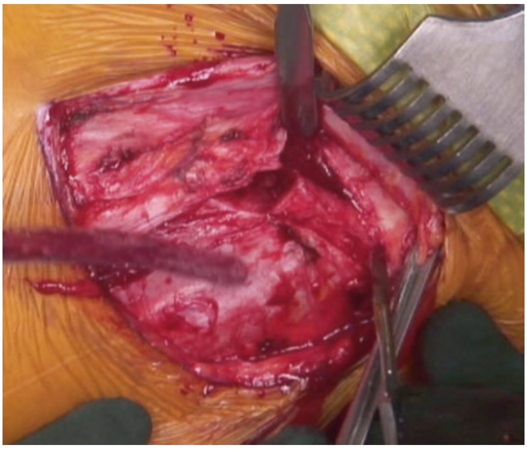

Fig. 12.5 After osteotomy of the anterosuperior iliac spine (ASIS), the abdominal muscles are sharply detached from the iliac crest, the iliopsoas is subperiosteally detached from the medial iliac wing using a sponge and retracted medially. The sartorius origin and inguinal ligament remain attached to the ASIS

gain access to the rectus femoris. The distal dissection should not go further down than the ascending branch of the lateral femoral circumflex artery, which crosses the interval between tensor and rectus, and needs to be preserved.

The abdominal muscles are detached from the anterior third of the iliac crest and the anterosuperior iliac spine (ASIS) is osteotomized and retracted medially with the sartorius insertion (Fig. 12.5). I prefer to realize an osteotomy, as I feel that the LFCN is better protected than by detaching the inguinal ligament subperiosteally [36]. The iliacus muscle is then subperiosteally detached from the iliac fossa with a sponge.

Further dissection is done by retracting the rectus origin laterally and detaching the iliocapsularis muscle origin from the AIIS and the anterior capsule. The psoas tendon and iliopectineal bursa are also lifted from the capsule, allowing a complete anteromedial exposure to the level of the calcar femoris, which can be palpated through the capsule. Adapted hip flexion and adduction may help during this dissection.

The fascia separating the posterior muscle compartment of the thigh is opened with the tip of long scissors, between the capsule and the psoas tendon, before palpating the ischiatic bone. The tip of the scissors may be moved medially and laterally to get a feeling of the width of the ischiatic bone.

12.6 Partial Ischial Osteotomy

A special osteotome with 30° angulation and a 15 mm blade (Ganz or periacetabular osteotome) is inserted into the space between the capsule and the psoas tendon. A similar but curved osteotome has been developed, which makes the ischiatic osteotomy easier in the author's hands.

The hip is abducted to lateralize and protect the sciatic nerve. The infracotyloid groove (notch between the posteroinferior acetabular wall and the ischium) is palpated and the chisel seated in the correct position, which can be verified using fluoroscopy (Fig. 12.6a). This control is helpful, all the more during early experience, but not mandatory in experienced hands. Care should however be taken in retroverted hips as the posterior horn of the acetabulum is less prominent than in dysplasia, which makes palpation more difficult and increases the risk for an intra-articular osteotomy. The osteotome should always aim toward the opposite shoulder to avoid a lateral orientation of the cut, which could injure the sciatic nerve [36]. It is then hammered into the bone to a depth of 3–4 cm, but not deeper as this osteotomy is incomplete to preserve the integrity of the posterior column. The curvature of the osteotome helps

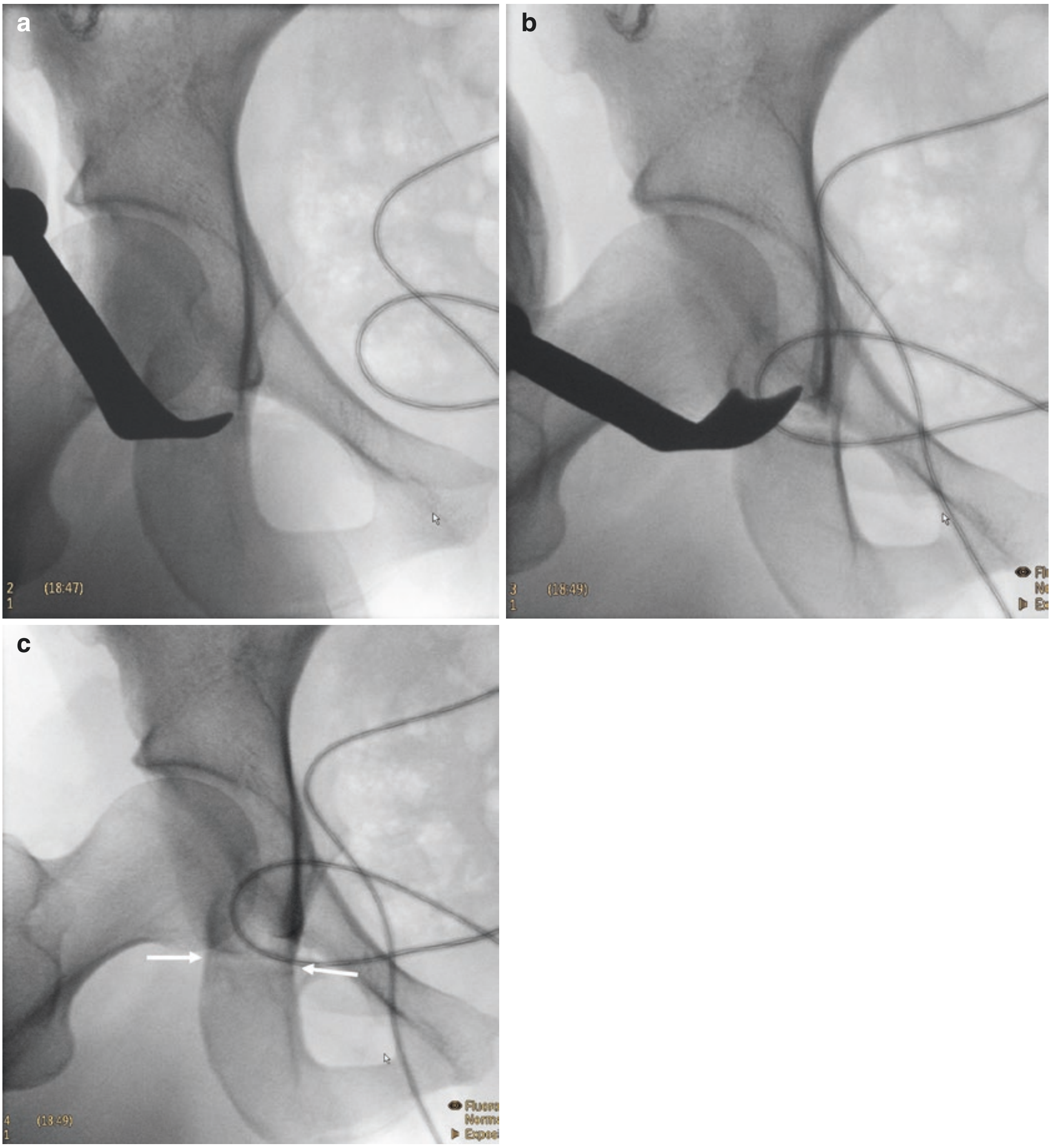

Fig. 12.6 (**a**) Fluoroscopic control of positioning of the curved Ganz osteotome in the infracotyloid groove. (**b**) Fluoroscopic control of positioning for cutting the lateral cortex. The chisel is oriented toward the opposite shoulder to avoid the closely located sciatic nerve. The hip is abducted and externally rotated to further protect the nerve. (**c**) Fluoroscopic control showing the osteotomy of the full width of the ischium (between arrows)

to curve the osteotomy upwards, parallel to the posterior wall and aiming at the ischiatic spine. After palpation and displacement of the osteotome medially in the first cut, a second more medial osteotomy is performed, allowing to cut the medial cortex. A lateral displacement from the first osteotomy allows to cut the lateral cortex, which should only be scored (Fig. 12.6b). In no case should the osteotome be advanced further than 10 mm at this level as the sciatic nerve is close [37]. Finally, after removal of the osteotome, a radioscopic control may be obtained to make sure that the whole width of the ischium has been osteotomized (Fig. 12.6c).

12.7 Pubic Osteotomy

The pubic ramus is exposed by hammering a pointed Hohmann retractor into the bone 2 cm medially of the ilio-pectineal eminence. This protects the psoas and overlying neurovascular structures. The thick periosteum is then incised longitudinally over the bone and two blunt retractors are placed subperiosteally proximal and distal of the ramus. A complete transverse, medially oblique (45°) osteotomy of the pubis is performed medially of the ilio-pectineal eminence with a chisel. The oblique orientation avoids articular penetration of the osteotome and also decreases the risk of lesion of the underlying obturator neurovascular bundle. The medial pubic ramus should move as the osteotome is moved to be sure that the osteotomy is complete.

In cases of retroversion, it is useful to resect a small piece (2–3 mm) of proximal cortex at the level of the osteotomy to decrease the risk of cortical blocking during repositioning of the fragment.

12.8 Supra- and Retroacetabular Osteotomies

After lifting the iliacus muscle from the inner iliac wing, a nutrient artery to the iliac bone of the ilio-lumbar artery may bleed above the pelvic brim [38]. As the artery retracts into the bone, it needs to be stilled by drilling a hole to increase the size of the nutrient foramen, which is then filled with bone wax.

Further endopelvic exposure is achieved by blunt dissection over the quadrilateral surface from the ischiatic notch to the obturator foramen. A reverse Eva retractor or pelvic retractor is then positioned at the level of the ischiatic spine.

On the outer aspect of the pelvis, the gluteus minimus and medius are tunnelized between the ASIS and AIIS toward the sciatic notch to place a blunt retractor, which protects the muscles and the sciatic nerve. This limited dissection protects the insertions of the tensor fasciae latae and gluteus minimus, as well as the inferior branch of the superior gluteal artery, which is important for the vascularization of the fragment [38].

The iliac (supraacetabular) osteotomy, which is realized with an oscillating saw, is a horizontal osteotomy above the acetabulum, starting immediately under the ASIS and going toward the pelvic brim. As the patient is lying supine, the orientation of the saw blade is strictly vertical. Depending on the pelvic shape, the osteotomy stops 1–2 cm above the pelvic brim.

The retroacetabular osteotomy, using a chisel, starts from the most posterior part of the iliac cut and is oriented distally by 100–120°, aiming at the tip of the retractor placed on the ischiatic spine (Fig. 12.7). Furthermore, the ischiatic notch can be palpated to be sure not to enter it, as this would interrupt the posterior column. A bone bridge of at least 1–2 cm should be preserved. The depth of this osteotomy is approximately 4 cm.

Fluoroscopic control of this osteotomy can be used, but I feel that a digital palpation of the sciatic notch is secure enough to orient the osteotomy correctly without fluoroscopy.

The outer cortex of the iliac bone is cut with a curved Simal osteotome, which is placed in the superior part of the retroacetabular osteotomy and aims laterally.

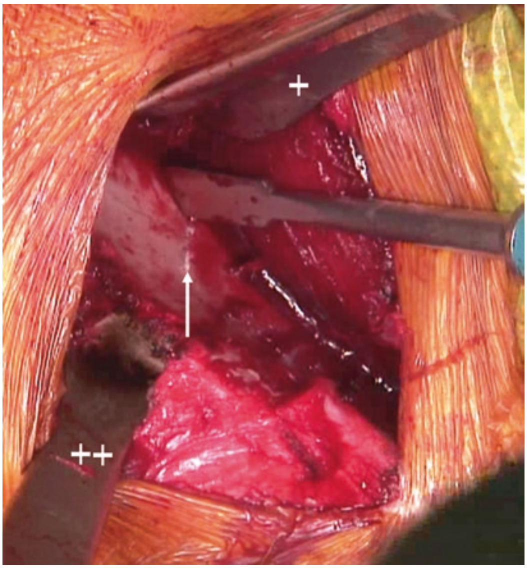

Fig. 12.7 After the horizontal supraacetabular osteotomy (arrow), the retroacetabular osteotomy starts from the most posterior part of the previous cut and is oriented distally by 100–120°, aiming the osteotome at the tip of the retractor (+) placed on the ischiatic spine. The lateral retractor (++) is placed in the sciatic notch to protect the sciatic nerve during these osteotomies

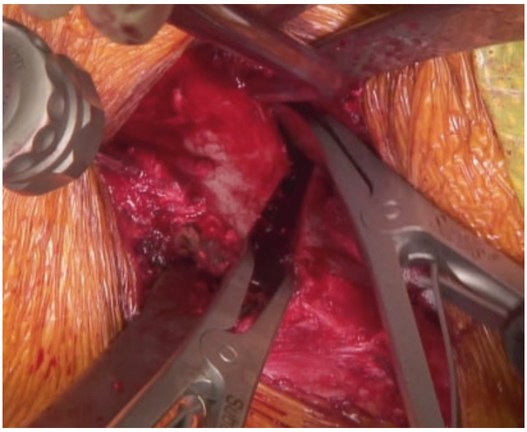

Fig. 12.8 Insertion of a Schanz screw into the anteroinferior iliac spine (AIIS) and distraction of the supra- and retroacetabular osteotomies, using laminar spreaders, to put them under tension

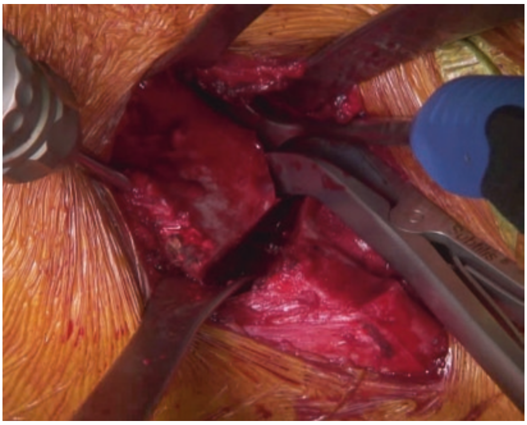

Fig. 12.9 The angled Ganz osteotome is placed into the retroacetabular osteotomy, 4 cm under the brim and aiming toward the first ischiatic osteotomy

At this point, a 5 mm Schanz screw is placed into the AIIS, aiming posteriorly in the supraacetabular bone. First the supraacetabular and second the retroacetabular osteotomies are distracted using a laminar spreader to put the osteotomies under tension (Fig. 12.8).

A special osteotome with 30° angulation and a 20 mm blade (Ganz or periacetabular osteotome) is then used to complete the osteotomy of the quadrilateral surface toward the first ischiatic cut (Fig. 12.9). This osteotomy starts 4 cm below the pelvic brim, with the handle of the osteotome pointing vertically. This angulates the osteotomy 50° compared to the quadrilateral surface. The angulation of this osteotome is placed at 4 cm from the tip, which helps positioning. The osteotome is sequentially displaced towards the obturator foramen to join the ischiatic osteotomy. Care should be taken to abduct the leg and avoid a complete penetration of the osteotome, as the sciatic nerve is lying just lateral to the ischium at this level [36].

As an alternative, the Ganz osteotome can be placed in the retroacetabular osteotomy, at 4 cm depth from the brim, and turned distally toward the ischiatic osteotomy, which allows to cut the inner cortex of the quadrilateral surface only, thus decreasing the risk of lesion to the sciatic nerve.

Loosening of tension in the laminar spreader indicates breaking of the bone. A counter-directed movement of the Schanz screw with internal rotation and the laminar spreader with external rotation allows to completely free the fragment from the stable pelvic bone (Fig. 12.10). If the fragment is not fully mobile, the osteotomies should be rechecked to be sure they are complete. Most frequently, the ischiatic osteotomy is insufficient and needs to be completed, either by restarting as described above for the ischiatic osteotomy or from the quadrilateral plate.

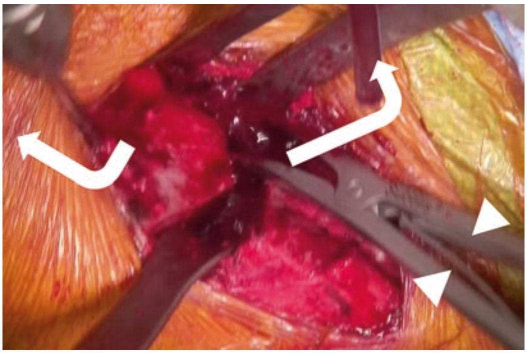

Fig. 12.10 Compression of the laminar spreader (arrowheads) and counter rotation (arrows) of the Schanz screw, and the spreader complete the osteotomies (directed fractures) to completely free the fragment

12.9 Mobilization and Reorientation of the Acetabular Fragment

Correction of the retroverted acetabulum is achieved by internal rotation of the fragment around the longitudinal axis (Fig. 12.11). The amount of correction varies with the importance

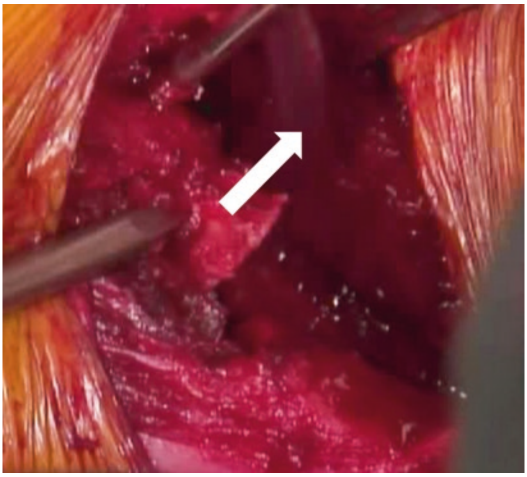

Fig. 12.11 Repositioning of the fragment with internal rotation (arrow)

of retroversion. Additional medialization or lateralization of the fragment must be adjusted individually in each patient, to optimize the balance between anterior and posterior wall. The fragment is then temporarily fixed by two threaded 2.5 mm Kirschner (K) wires.

In cases with an inverted acetabular roof, additional extension of the fragment along the transversal axis is necessary to obtain a horizontal sourcil and avoid increasing lateral coverage of the femoral head. As extension is often limited, a lateral-based bone wedge should be resected from the cranial acetabular fragment, the angulation of which corresponds to the needed correction. The supraacetabular osteotomy should then be closed to achieve the extension. This is frequently the most difficult correction as bone spikes at the level of the ischiatic osteotomy may hook the fragment. This one can be lifted, if necessary, by placing the Ganz osteotome into the ischiatic osteotomy, but taking care not to push the blade of the osteotome laterally to avoid the sciatic nerve.

12.10 Intraoperative Controls: X-Rays and Joint Mobility, Definitive Fixation

A radiological control of the accuracy of reorientation is mandatory. This may be achieved with an ap pelvic radiograph or by using fluoroscopy [32, 39]. Fluoroscopic imaging is my preferred way of doing because of its easy handling, but extreme care should be taken in positioning the device to achieve a reproducible and correct image of the 3D orientation of the acetabulum [39].

Analysis of the orientation should show no more cross-over sign and a positive posterior wall sign. The lateral coverage should not be excessive (lateral center-edge [LCE] angle no more than 33°) and the sourcil must be horizontal [40]. The joint space should also be congruent. The only sign that will not be changed is the ischiatic spine sign, as the posterior column is not reoriented with this type of osteotomy (Fig. 12.12).

As retroversion is more difficult to correct than dysplasia, several attempts to find the correct position may be necessary. In complex acetabular deformities, it may be necessary to accept a compromise in positioning, but accurate joint mobility will indicate whether this compromise is acceptable or not.

Once a satisfactory correction has been obtained, definitive fixation is achieved with two 3.5 mm screws from the iliac crest, replacing the K-wires, and one to two horizontal screws from

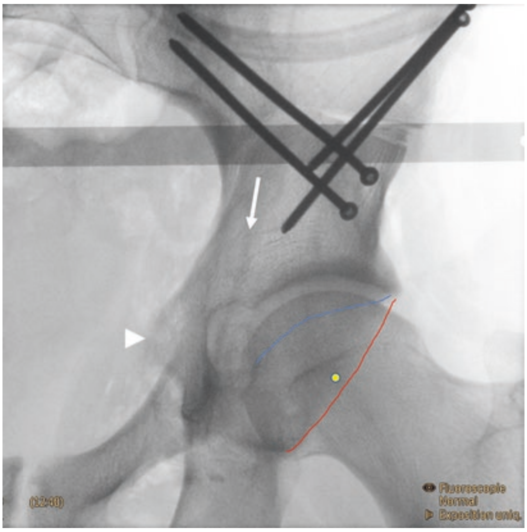

Fig. 12.12 Final fluoroscopic control before recontouring of the femoral head. Correct orientation of the acetabular walls (anterior blue, posterior red), meeting at the lateral sourcil and without cross-over. The head center (yellow dot) is medial of the posterior wall. Good joint congruency. The ilio-ischiatic line (arrow) is complete, confirming the absence of osteotomy of the posterior column. The ischiatic spine (arrow head) is still prominent as it was not included in the reorientation

the AIIS. Additional fixation is rarely needed, only in cases with major corrections.

Frequently, a bone spike from the interspinous crest is found above the AIIS. This is osteotomized and inserted into the supraacetabular osteotomy gap to promote consolidation.

The second mandatory control is joint mobility to exclude residual impingement. In 90° of flexion, an internal rotation of 30° should be achieved. If this is not the case, either should the acetabular fragment be repositioned, or the femoral head–neck offset corrected. This can also be predicted from the preoperative X-ray analysis showing a decreased offset. In their study, Siebenrock et al. found up to 92% of cases needing an osteochondroplasty after acetabular reorientation [41].

12.11 Hip Joint Arthrotomy

If 30° of internal rotation in 90° flexion is not achieved, an anterior arthrotomy must be performed. The capsule is opened with a T-shaped incision and retracted, taking care not to cut the labrum (Fig. 12.13). The use of a blunt retractor inside the capsule helps the exposition, as well as an alternate medial or lateral retraction of the rectus femoris tendon, which does not need to be detached in this way.

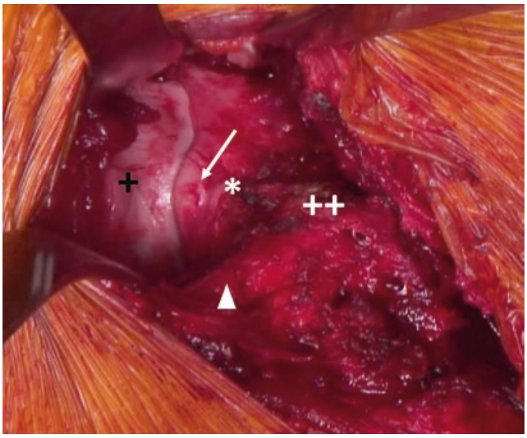

Fig. 12.13 After arthrotomy, visualization of the femoral head (+), the anteroinferior iliac spine (AIIS: ++), and the rectus femoris tendon (arrow head), which is retracted laterally. The AIIS is quite prominent, going straight down to the acetabular rim (asterisk). The arrow points to a deformation of the labrum due to a base ossification, which can be resected before refixation of the labrum

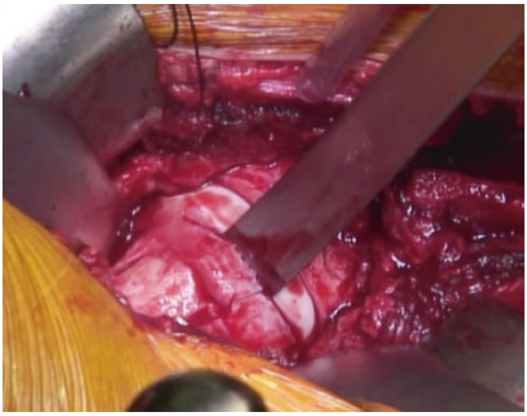

Fig. 12.14 Recontouring of the femoral head, here with a curved osteotome

At this point, the morphology of the AIIS is analyzed, as it is frequently too prominent and induces a so-called subspine impingement [42]. As with arthroscopic techniques, the base of the AIIS is recontoured as deep as necessary to avoid an abnormal contact with the femoral neck, but without harming the overlying rectus femoris tendon.

Based on the preoperative imaging and the intraoperative testing, an osteochondroplasty of the femoral head–neck junction is done, either using osteotomes or a high-speed burr (Fig. 12.14). The head–neck offset should be reshaped to normal, which is controlled by achieving 30° of internal rotation.

12.12 Closure

After lavage of the joint to remove any bone debris, the capsule is closed without tension. The ASIS is repositioned and fixed with a 3.5 or 2.7 mm screw. Refixation of the abdominal muscles and closure of the fascia of the tensor fasciae latae are done. Routinely, no drainage is used.

12.13 Postoperative Reeducation

The leg is positioned in slight abduction in a soft splint. Partial weight-bearing of the operated leg with 10–15 kg is started from day 1 for 8 weeks. Passive motion using a continuous passive motion (CPM)-machine is also started from day 1. In my experience, this helps in recovering a better joint motion and patients feel decreased pain after exercising. Isometric strengthening and stretching exercises are also started from day 1.

After 8 weeks, radiographs show callus formation and the supra- and retroacetabular osteotomies become less visible as signs of consolidation (Fig. 12.15a–c). Progressive weight-bearing as tolerated is then allowed and formal physiotherapy started.

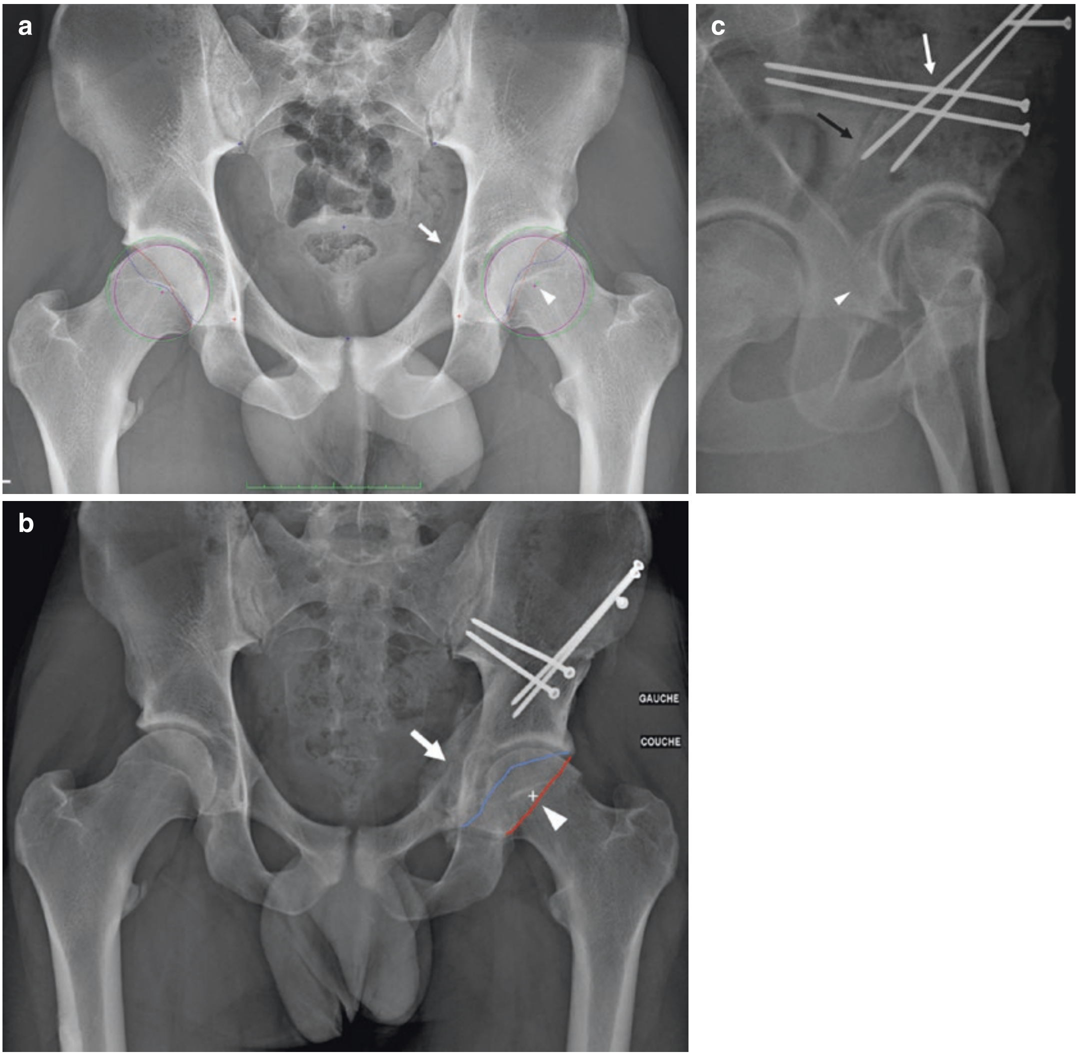

Fig. 12.15 (**a**) A 20-year-old male patient with painful impingement of the left hip. The correctly centered anteroposterior (ap)-pelvis X-ray shows a low cross-over between the anterior (blue) and posterior (red) acetabular walls. The femoral head center is lateral of the posterior wall (positive posterior wall sign) and the ischiatic spine is visible (positive ischiatic spine sign). (**b**) Ap-pelvis 2 months after a reverse periacetabular osteotomy (PAO) and offset correction. The anterior (blue) and posterior (red) walls do not cross anymore; the femoral head center is medial of the posterior wall (arrow head). In this case, the ischiatic spine (arrow), which would remain visible as the posterior column is preserved, is hidden by the prominent pubic ramus and callus. (**c**) On the false-profile view, the supraacetabular (white arrow), retroacetabular (black arrow), and ischiatic (arrowhead) osteotomies show good signs of consolidation. The absence of lesion of the posterior column is nicely visible behind the retroacetabular osteotomy

12.14 Results

Hartigan et al. reviewed their results of arthroscopic treatment for acetabular retroversion [43]. At 2-year follow-up, they found 99% survival, one patient needing a total hip replacement (THR) after 6 months, and no progression of osteoarthritis. The Non-Arthritic Hip Score (NAHS) progressed from 65 to 86 points. Such results seem interesting, but based on the basic biomechanic problem of retroversion and the knowledge of the anatomic shape of the acetabular walls, caution must be used when proposing such a treatment. Furthermore, we only have short-term results after such treatments, which does not allow to state about their final adequacy.

Flores et al. show good clinical results after arthroscopic rim decompression in retroversion, which are even increased in cases with simultaneous subspine decompression. They however only have a follow-up of 1 year, which is not sufficient to state about the adequacy of such a treatment regarding evolution to osteoarthritis [44].

Parry et al. analyzed mid-term results after reverse PAO with or without dysplasia [45]. After 5 years, no patient showed progression to osteoarthritis and the mean modified Harris Hip Score (HHS) progressed to 93, respectively 92, points.

In a systematic literature review, Litrenta et al. found significant clinical improvements, low progression of arthritis with a follow-up up to 5.5 years, low revision rates, and complications with arthroscopic and open techniques [46]. However, even if arthroscopy has a proven role, they suggest that hips with greater retroversion or dysplasia may benefit from a reorientation procedure rather than arthroscopy.

Peters et al. describe their algorithmic approach, analyzing the acetabular morphology in terms of dysplasia and wall orientation [47]. The amount of posterior and lateral acetabular coverage is of paramount importance. Normal coverage with surgical hip dislocation (SHD) will give good results, whereas deficient coverage will indicate a reorientation procedure. They state that decision-making regarding the best treatment is difficult and needs thorough consideration of the 3D morphology of the hip.

The Bernese group reviewed their results when treating true retroversion, comparing SHD with reverse PAO [48]. At 5 years, the survival is identical, but SHD shows a steep decrease thereafter. At 10 years, they only found 23% survival with SHD, whereas PAO still showed a survival of 79%, decreasing to 73% at 15 years.

They state that the decrease in surface of the anterior acetabular wall produces an iatrogenic dysplasia, which accelerates joint deterioration. Therefore, resection of the anterior wall is critical and should only be done, using SHD or arthroscopy, in cases with acetabular overcoverage and not true retroversion.

12.15 Conclusion

In a setting with true acetabular retroversion, acetabular rim trimming is contraindicated, except in rare situations where reorientation of the acetabulum would move cartilage defects into the weight-bearing zone. A precise morphologic diagnosis is mandatory to avoid under- or overtreating these cases.

Periacetabular osteotomy is tricky surgery, which however can be learnt. Knowing the difficulties, the technical tricks as well as perseverance until an optimal correction in terms of socket orientation has been obtained allow to achieve reproducible good results with this technique.

Technical Pearls

A precise radiological diagnosis of the acetabular deformation is mandatory.

A correctly centered ap pelvic view is the road map to evaluating the deformation and the appropriate correction in three dimensions.

No major acetabular cartilage damage should be found anterior and lateral on arthro-MRI or arthro-CT if a reorientation is planned.

In true retroversion, a reorientation periacetabular osteotomy is superior to rim trimming.

Because of a better cosmetic result, a bikini-type incision is preferred.

The approach is a modified Smith-Peterson approach.

An osteotomy of the anterosuperior iliac spine is preferable to subperiosteal detachment of the inguinal ligament, because it better protects the lateral femoral cutaneous nerve.

The ischial osteotomy should be realized under fluoroscopic control, at least during initial experience, to secure the positioning and orientation of the osteotomy. Correct placement of the osteotome is more difficult in retroversion, as the posterior horn of the acetabulum is turned backwards and thus less prominent. An osteotomy depth of 3 cm should be obtained to later achieve an easy mobilization of the fragment.

The pubic osteotomy must be oriented medially and transverse to the longitudinal axis of the pubis to allow better rotation of the fragment.

The supraacetabular osteotomy is realized in a strictly vertical direction, starting from the anterior end of the anterosuperior iliac spine and ending 1–2 cm above the pelvic brim.

The retroacetabular osteotomy aims at the tip of a blunt retractor placed on the medial part of the ischiatic spine. Palpation of the ischiatic notch helps to ascertain a correct orientation of this cut, avoiding to interrupt the posterior acetabular column.

A distractor in the retroacetabular osteotomy allows to put the fragment under tension and to realize the osteotomy of the quadrilateral surface, aiming at the first ischiatic osteotomy.

Free mobilization of the fragment confirms complete osteotomies and is necessary to achieve a correct reorientation. Should this not be the case, the osteotomies should be sequentially recontrolled, starting with the ischiatic osteotomy as this is the most difficult one.

In cases with an inverted roof, a resection of a triangle at the level of the supraacetabular osteotomy may be helpful to correct the orientation of the roof by closing the supraacetabular osteotomy gap.

In pure retroversion, the basic correction of the fragment is in internal rotation, additional corrections depending on each individual morphology. Provisional fixation is achieved with Kirschner wires.

Radiological or fluoroscopic control of the correction is mandatory. If unsatisfactory, a new trial is necessary until a perfect correction is achieved! Definitive fixation is done with three to four 3.5 mm screws.

If hip flexion of 110° and internal rotation of 25° are not achieved with a correct reorientation, a recontouring of the anteroinferior iliac spine and femoral head–neck junction must be done, otherwise leaving the patient with an ongoing femoroacetabular impingement.

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13 Proximal Femoral Osteotomy

Frédéric Laude

13.1 Introduction

A common procedure some 50 years ago, it is hardly ever taught to new surgeons nowadays despite being the best osteotomy for correcting proximal femoral deformities.

Instead, hip replacement surgery has taken over and relegated it into oblivion. A firm favourite among older surgeons, who still uses the MacMurray procedure [4], and has anyone new even read the works of Bombelli? [5, 6]. Femoral osteotomy is only ever really performed in a paediatric setting where replacement surgery is not the first-line approach.

In addition, the procedure poses a certain number of recovery issues which are liked by no one, especially the patients. It is a very hard procedure to sell. The proximal femur takes a long time to heal. The resulting scarring is fairly extensive, and nearly every case will require removal of the material.

Femoral osteotomy also gained a reputation for altering the shape of the femoral medullary cavity and thus compromising any future hip replacement [7, 8].

However, if the surgeon is particularly keen on salvage surgery, there is sometimes no option other than to correct the femur in order to resolve an architectural defect. Osteotomy is therefore a procedure that, in the hands of a specialist, is still highly relevant within the therapeutic arsenal of salvage surgery [5, 9, 10].

13.2 The Traditional Surgical Approach

Osteotomies are traditionally performed via a lateral portal passing through the fascia lata down to the lateral aspect of the greater trochanter and the proximal vastus lateralis muscle. Vastus lateralis is detached from its insertion onto the greater trochanter. The osteotomy line tends to be more or less horizontal, usually passing between the lower part of the greater trochanter and terminating above the lesser trochanter. A number of different plates can be used, depending on the type of procedure. The most typical is the one made popular by Maurice Muller and the AO Foundation, namely, the blade plate [11]. It comes in various angles and lengths, can be used for all types of osteotomy and requires extremely careful preoperative planning.

The fixation device pierces the lateral aspect of the trochanter and lies on the outside of the diaphysis, requiring periosteal stripping. Patients are typically required to avoid bearing weight for 3 months, and full recovery is often achieved after 6 months. With a varus-producing osteotomy, patients are often very concerned and find it

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hard to come to terms with the difference in length and residual limp. There are ways to avoid any alteration in length, but it will result in significant changes to the shape of the femoral intramedullary cavity, something the surgeon will wish to avoid in case a hip replacement becomes necessary in the future. Once the bone has consolidated, the plate must be removed which requires a second invasive procedure for the vastus lateralis muscle and fascia lata.

13.3 Why Changes? Reasons for an Evolution

The need to avoid bearing weight and the lengthy recovery period is what make surgeons reluctant to offer a traditional osteotomy to their patients.

However, we believed that there was a way of simplifying the technique and making an osteotomy once more a relevant option by using an approach that is currently on track to regaining its former glory. Having gained confidence from our experience of in situ femoral neck resection during hip replacement surgery, we hypothesized that a femoral correction osteotomy could be performed using a minimally invasive Hueter approach.

Towards the end of the 1990s, we therefore began offering this technique [12] for the treatment of femoroacetabular impingement, and the potential visibility of the anterior proximal metaphysis and femoral epiphysis propelled us to perform the osteotomy via an anterior portal.

Another considerable benefit was that even a complex hip deformity would require only anterior access, thus better preserving the structures for any future joint replacement or revision surgery.

By accessing the femoral neck and proximal femur from the front, the osteotomy can be performed without touching any of the gluteal muscles and without the need to eliminate blood flow to the diaphysis through periosteal stripping. It is also entirely possible, thanks to the access to the femoral epiphysis and joint space, to correct any associated impingement, which is not possible using the traditional technique.

Finally, yet in our view most crucially, the osteotomy line can be a little higher than the traditional technique, thus having less effect on the shape of the femur. As and when the need for arthroplasty arises, the surgeon will not have to wrestle with any residual femoral deformation caused by the osteotomy [13].

Below, we report on our experience with femoral osteotomy using this anterior approach.

13.4 Minimally Invasive Hueter Anterior Femoral and Osteotomy Technique

This type of surgery is of course primarily indicated for young adults with a severe architectural deformity. Only very exceptionally is it for patients aged over 40, and, as with all types of hip salvage surgery, the cartilage should be carefully assessed (join scan) to ensure no excessive damage. If the Tönnis Grade is higher than 1, the surgeon should reconsider the suitability of this procedure, given the risk of a limited outcome.

We believe that a full assessment is necessary, including dynamic radiographs in abduction and adduction. This is now routinely accompanied by a scan with 3D reconstruction and a calculation of the femoral anteversion.

The more complex cases also benefit from EOS imaging.

The patient is placed on an orthopaedic traction table. The surgical fields are placed in exactly the same manner as for an anterior hip replacement on an extension table. The only difference is that the lateral femur must remain accessible, because the osteotomy correction is performed percutaneously using 2–3 cannulated screws.

In theory, the procedure does not require an image intensifier, although I do recommend using fluoroscopy to check the various stages, so the intensifier should be placed between the patient's legs.

The technique uses a minimally invasive anterior approach, identical to that used for an arthroplasty between tensor fasciae lata and rectus femoris. The innominate fascia is retracted to expose the anterior circumflex vessels which can be ligated without hesitation. Blood is supplied to the head of femur through the medial circumflex and not this anterior branch.

The capsule is opened using either an inverted V or T incision. The best method is to use traction thread with the capsule flap for easier manipulation and exposure. The capsule opening extends to the anterior tubercle of the greater trochanter, which marks the junction between the neck and metaphysis (Fig. 13.1).

Usually, slightly further back on the proximal aspect of the neck of femur, one can visualize the periosteal structure that supplies blood to the femoral head. This must of course remain intact, and the surgeon must take care to avoid the osteotomy line getting too close at any point.

A few millimetres of vastus lateralis may be disinserted at this point to assist the exposure.

The upper capsule opening extends to the labrum. An arthroscope may now be inserted into the joint, either using the existing portal or by making another entry point slightly offset in order to arrive more centrally into the joint. In this case, the arthroscopy is performed using air and does not require irrigation. The joint can now be placed in traction in order to explore the central compartment of the hip joint cavity. A cartilage assessment is a crucial stage of all salvage surgery. If there is any damage to the labrum or cartilage, the surgeon can of course proceed with reparative surgery. Those with sufficient experience in hip arthroscopy can even turn on the water, remove the retractors and treat the impingement.

It is even possible to dislocate the hip anteriorly if the femoral head requires a particularly specialist procedure such as a mosaicplasty cartilage transplantation [14].

Whatever osteotomy has to be performed, the first line is horizontal and concerns the inner half of the femoral metaphysis. It terminates beneath the trochanteric tubercle to avoid damage to the gluteus minimus tendon (Fig. 13.2).

For a varus-producing osteotomy, a wedge can be removed from the medial base, matching the desired angle of correction. The higher the line, the more accurate the wedge calculations must be because it is easy to exaggerate the varus correction by having the line too close to the neck. The preoperative planning must be just as meticulous

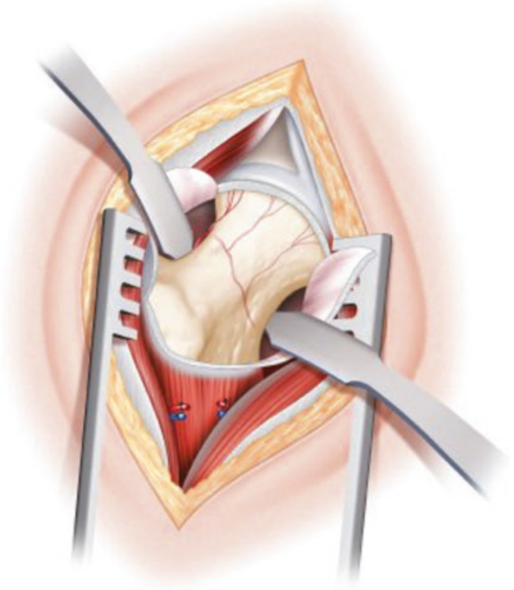

Fig. 13.1 Minimally-invasive Hueter approach. The procedure generally requires only a 5–6 cm incision. The portal can of course be widened for easier access

Fig. 13.2 Whatever the osteotomy to be performed, the first line is horizontal and concerns the inner half of the femoral metaphysis. It terminates beneath the trochanteric tubercle to avoid damage to the gluteus minimus tendon

as for the traditional technique. In principle, I suggest having the first line as horizontally as possible and then placing the second line above or under the first to create the osteotomy wedge (Fig. 13.3a).

The wedge should be incomplete and should not entirely section the lateral femur by the greater trochanter. The cancellous bone in this region will naturally break more towards the top in general. Simply stop the oscillating saw halfway between the lateral and medial cortex, just at the point of insertion of vastus lateralis beneath the trochanteric tubercle. The orthopaedic table is then put in compression

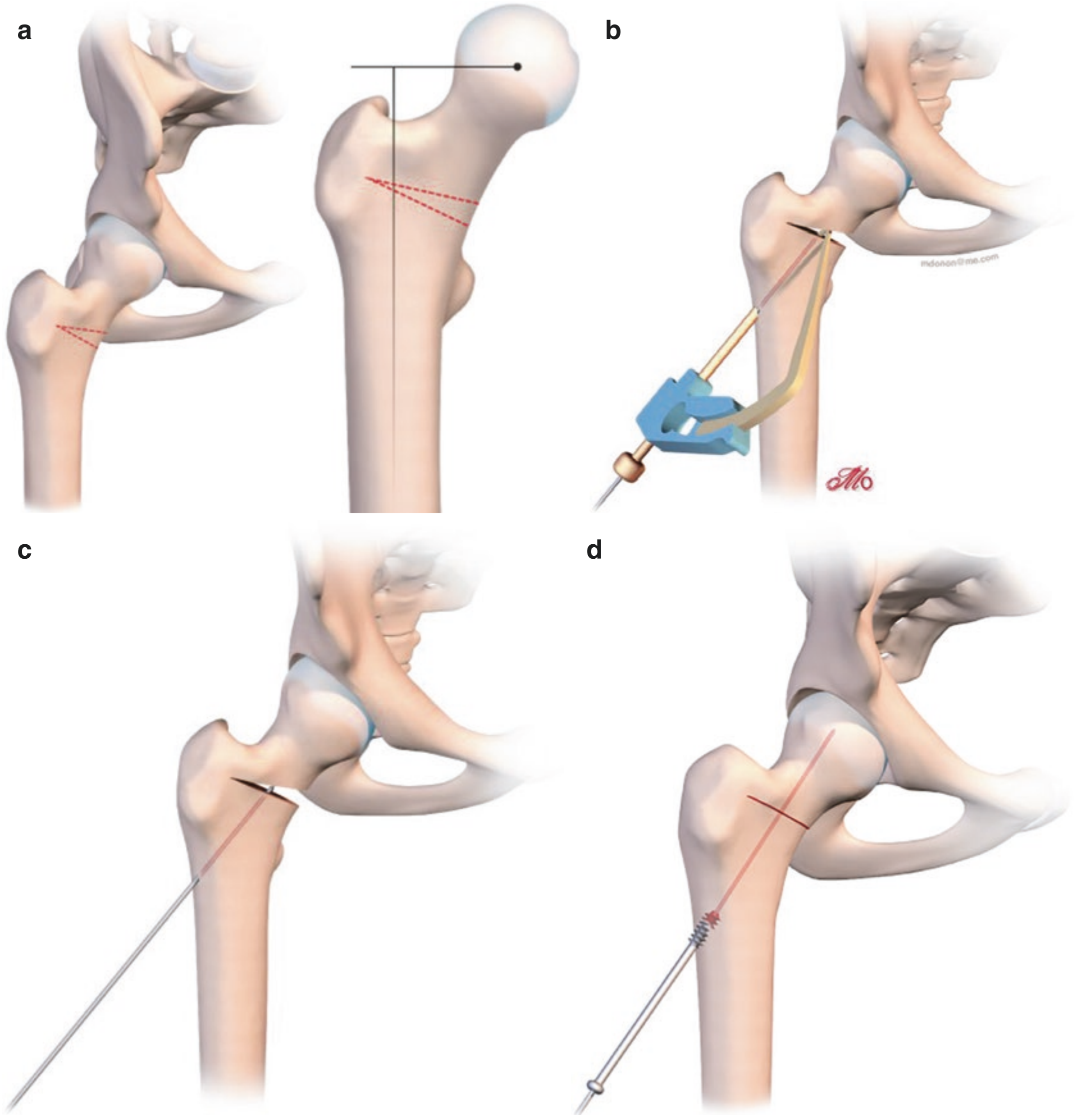

Fig. 13.3 (**a**) Femoral varisation osteotomy. Presurgical planning and position of the osteotomy wedge to be removed. (**b**) Inserting a pin with the tibial drill guide used for ACL repair. (**c**) The pin sits within the osteotomy line and goes no further. (**d**) The osteotomy line is placed under compression using the osteotomy table; the closure of the line results in osteoclasis in the greater trochanter. The pin is then pushed into the head to stabilise the fixation, and a cannulated screw is used to guarantee osteosynthesis. (**e**) The fixation is completed with a second screw. (**f**) Final assembly with correction

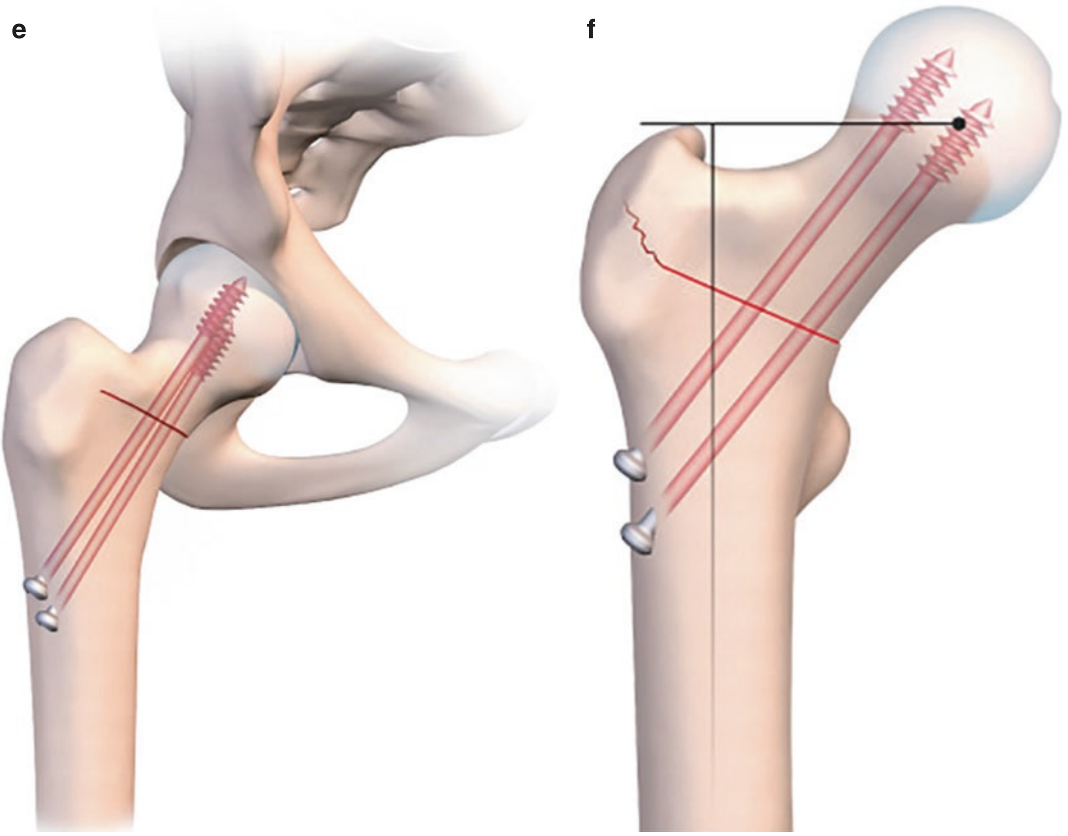

Fig. 13.3 (continued)

and the open osteotomy line will close fairly naturally. If there is any resistance, the line can be completed laterally using a chisel in order to encourage the fracture towards the greater trochanter.

At no point should the gluteal muscles or fascia lata be involved, and by remaining intact, these muscular/aponeurotic structures will act as a lateral tension band.

This osteotomy is easy to fix, using the same technique as for a normal impacted fracture of the base of the neck of femur, with two or three large diameter cannulated screws.

Just before using the orthopaedic table to begin the compression, it is a good idea to use a tibial drill guide as for cruciate ligament repair (Fig. 13.3b).

This makes it much easier to guide a pin into the osteotomy line that has just been created. The pin should of course sit just within the osteotomy line, without going any further (Fig. 13.3c).

Applying compression will close the line and fix the pin in the neck and head of femur.

With the osteotomy line closed and the pin in place, the final stage is to insert a 7-mm cannulated screw to stabilize the fixation (Fig. 13.3d).

A second or even third screw may be used if necessary. The image intensifier should be used to check the correct placement of the screws (Fig. 13.3e, f).

For a valgus osteotomy (Fig. 13.4), the technique is even simpler as one single osteotomy line is required in the medial half of the femur (Fig. 13.5a).

Simply applying traction along the line of the femur will naturally cause the osteotomy line to open. The line should be incomplete, and the lateral part should again be created as for a guided

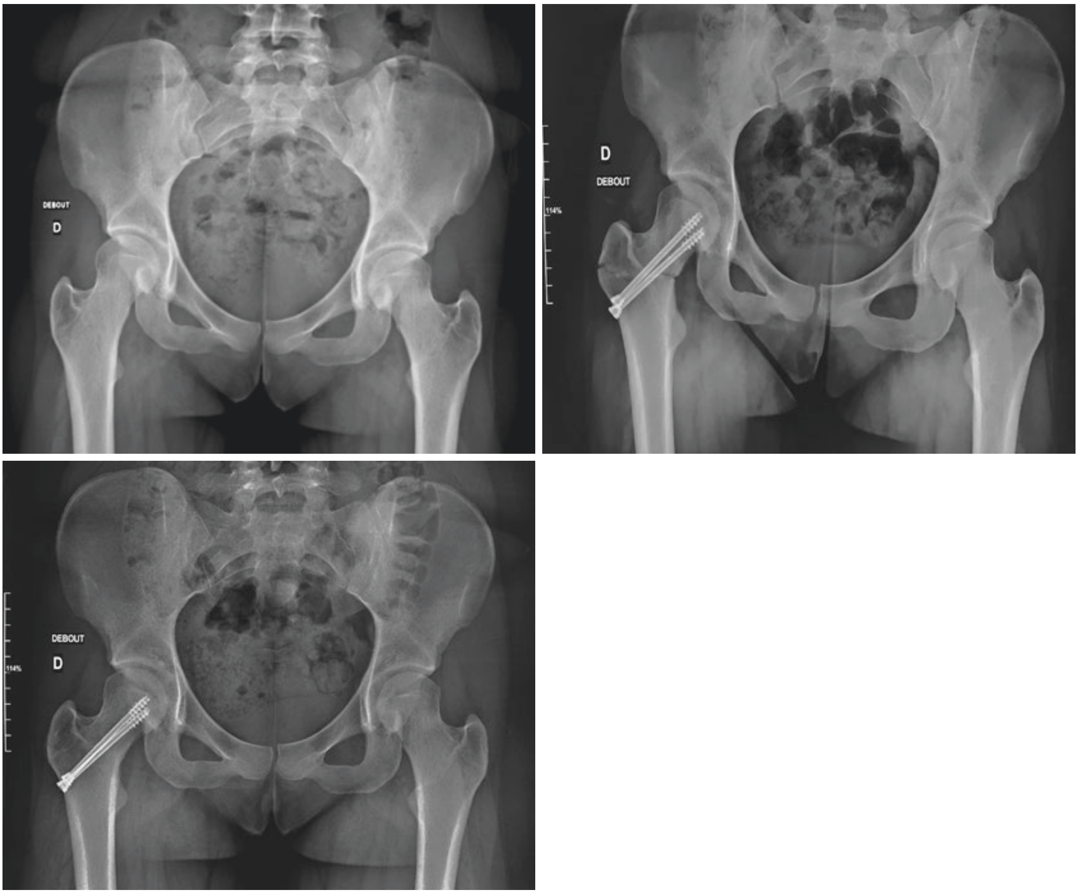

Fig. 13.4 Varization

bone fracture. The medial section of the line is then opened by putting the orthopaedic table in traction.

It is quite possible and even desirable to improve the outcome and avoid any loss of correction upon weight-bearing, to insert a hydroxyapatite wedge into the open line (Fig. 13.5b).

However, the fixation process is trickier, because the cannulated screw must not create any new compression which would close the line. I recommend using a large diameter fully threaded cortical screw as close as possible to the medical cortex into the femoral neck where the bone stock quality is highest. A second more lateral screw will maintain a good degree of compression on the lateral part of the line. In addition, here the screw will embed into the cancellous bone of the greater trochanter (Fig. 13.5c).

A wedge could be harvested from the iliac crest in order to fill the gap, but this would be insufficient on its own to produce the desired degree of valgus. When the patient tries to bear weight on the region, the line will be unable to close and crush the wedge. The medial-most fully threaded screw will be more effective if seated in the lateral cortex of the lateral diaphysis and firmly embedded in the head (Fig. 13.6).

This technique is also very useful for version correction osteotomies at the base of the neck to treat excessive anteversion of the femoral neck. The problem can be corrected at the point of the problem instead of at the femoral diaphysis as when using an intramedullary nail. The need for rotation requires complete mobilization of the neck, involving a double osteotomy line in order to avoid mobilizing the greater trochanter. This

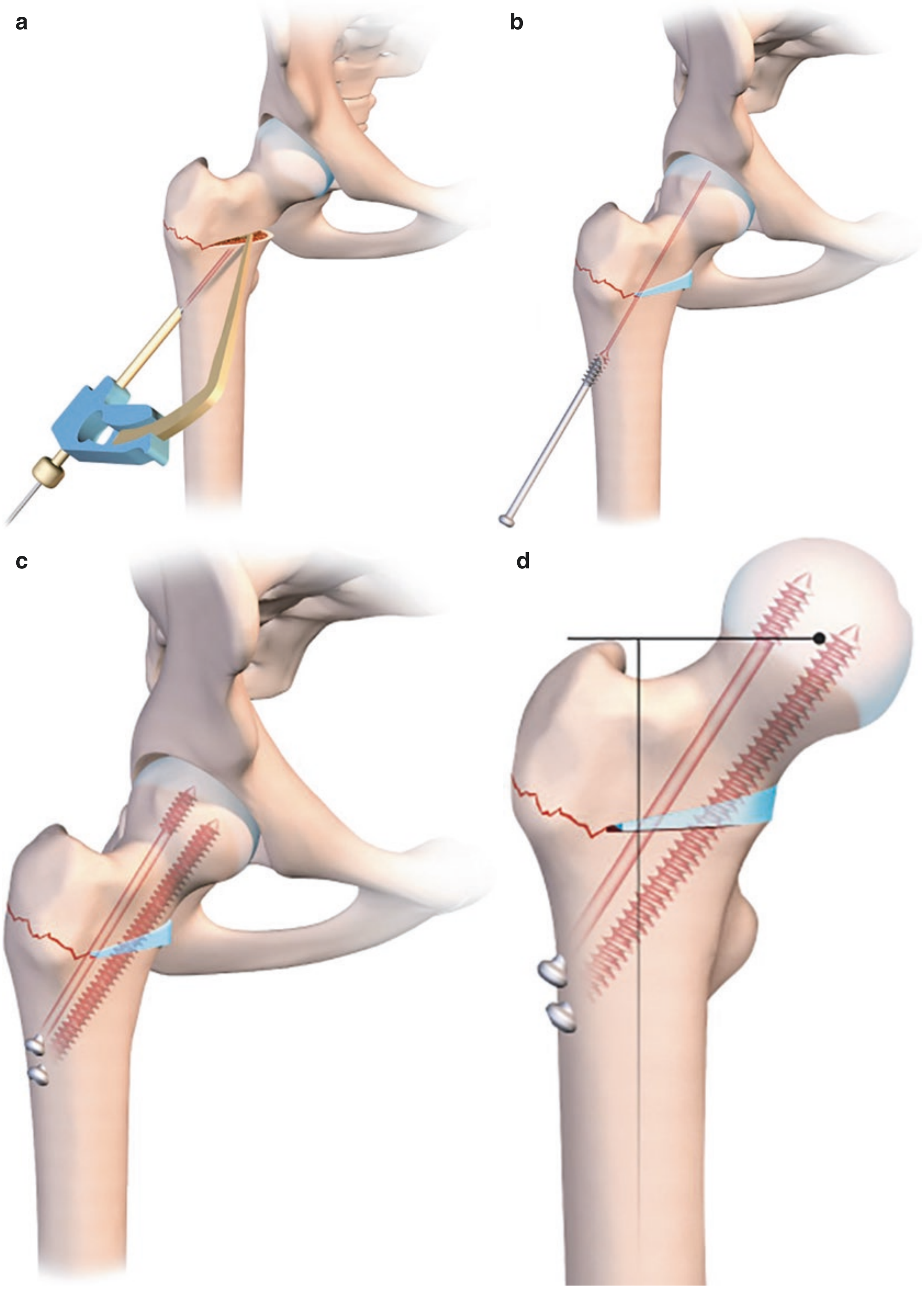

Fig. 13.5 Valgization. (**a**) Valgization technique: incomplete osteotomy line perpendicular to the diaphysis. The limb is then placed in traction using the orthopaedic table. The osteotomy line is opened to the angle needed to correct the deformation. The angle is checked using an image intensifier. (**b**) A strong and solid HAP wedge keeps the valgus osteotomy open, and the wire is pushed inside the femoral head. (**c**) A second fully threaded screw stabilizes the fixation and prevents any loss of correction. (**d**) Final fixation

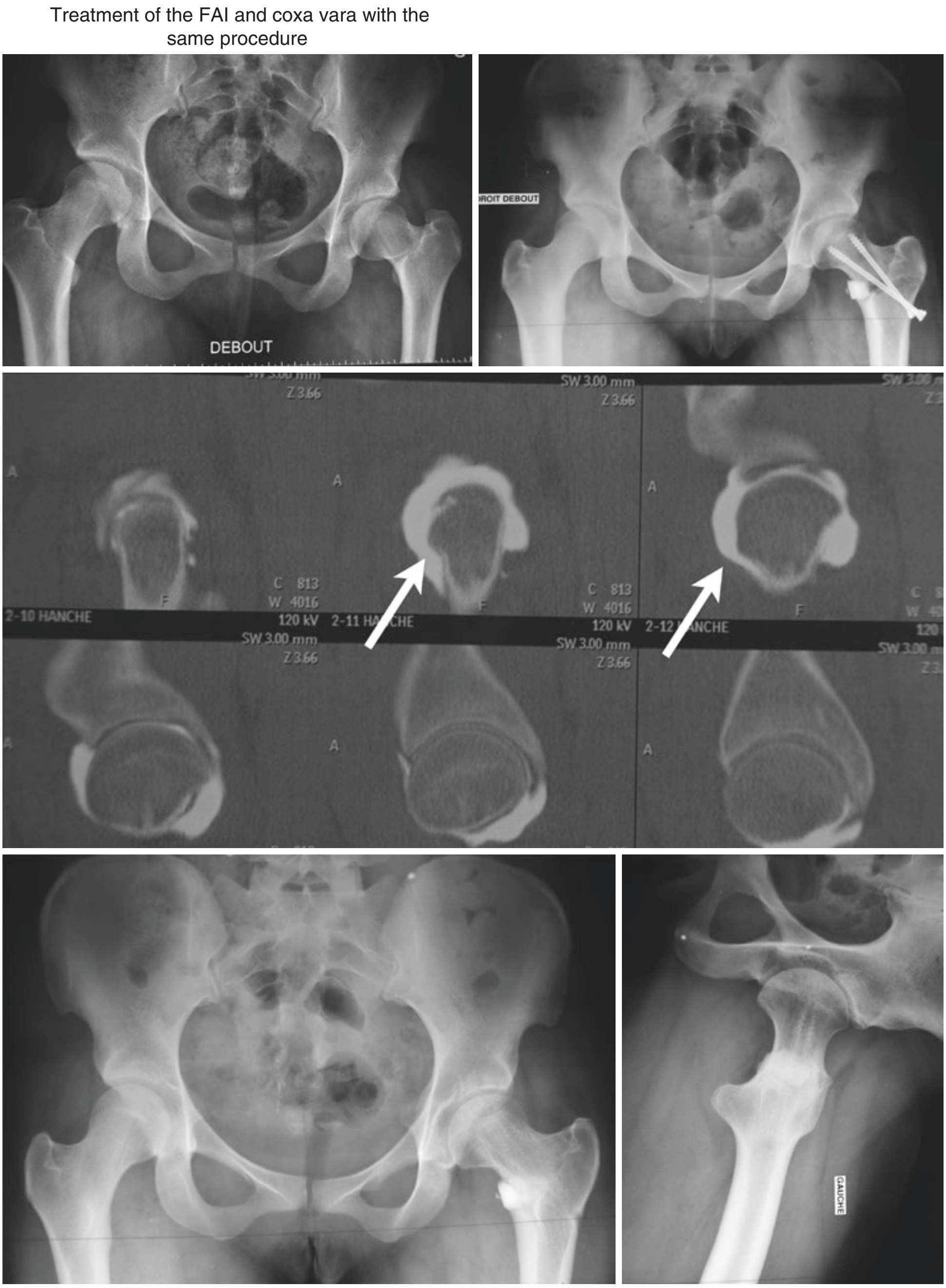

Fig. 13.6 Valgization example: treatment of FAI and coxa vara with the same procedure

post opt incision

Fig. 13.6 (continued)

line runs perpendicular and vertically terminates in the greater trochanter (Fig. 13.7a, b) just behind the origin of the femoral neck, leaving the periosteum intact. The line is usually incomplete.

In order to guarantee avoiding the blood vessels when creating this second vertical line, I recommend resection of the anterior cortex only. This will leave a posterior bony hinge to protect the median circumflex vessels.

The foot is placed in sharp medial rotation; then, an osteotome is inserted into the vertical line. The foot and knee are then returned to neutral rotation (Fig. 13.7c). The osteotome holds the neck in medial rotation by opening the derotation osteotomy. The posterior cortex will break naturally and automatically create a posterior hinge.

No tool or instrument should bypass this potentially dangerous region. If the vertical line is sufficiently posterior, there is no great risk since the vessels run in close contact to the femoral neck (Fig. 13.7a). It reaches the neck after passing between the medial and lateral obturator muscles.

Before making the two osteotomy lines, the whole procedure can be made easier by drilling a 3.5-mm hole in the anterior cortex anterior to where the two perpendicular lines will join and using an image intensifier to ensure the optimal positioning of the two osteotomy lines (Fig. 13.7a).

With derotation osteotomies, we fill open lines using a small allograft fragment (Fig. 13.7d). Two or three large diameter cannulated screws will hold the epiphyseal fragment (Figs. 13.7e and 13.8).

13.5 Results

We began performing this procedure in 2008 the decade since we have corrected 15 hips in 14 patients. They were all young patients with an average age of 24 (range 17–34) for whom replacement surgery was a very aggressive option. Ten of the patients were women (11 hips), and four were men. Average follow-up is 4 years (range 6 months–10 years).

Nine of the corrections involved a varus-producing osteotomy, five a valgus-producing osteotomy and one femoral derotation for excessive femoral anteversion.

Two patients underwent a simultaneous periacetabular osteotomy. In one of these two cases, involving a young 27-year-old patient, the periacetabular and varus osteotomy were accompanied by a cartilage transplantation using the mosaicplasty technique with anterior femoral dislocation. All three procedures were of course performed through the same portal.

If there were any femoroacetabular impingement requiring targeted treatment [15], the procedure was performed prior to the osteotomy.

We found that recovery was much faster than the traditional technique, and in 14 out of the 15 cases, the patient was able to bear full weight on the joint within 2 months.

All hips consolidated in under 3 months, except one which took closer to 4 months.

In this particular case, involving a relatively high osteotomy line, we had instructed the patient to wait 4 months before bearing weight.

The Harris Hip Score increased from a preoperative 60 to 90 as of the final follow-up (range 80–97).

Unfortunately, in one of the very first cases we handled involving a valgus-producing osteotomy,

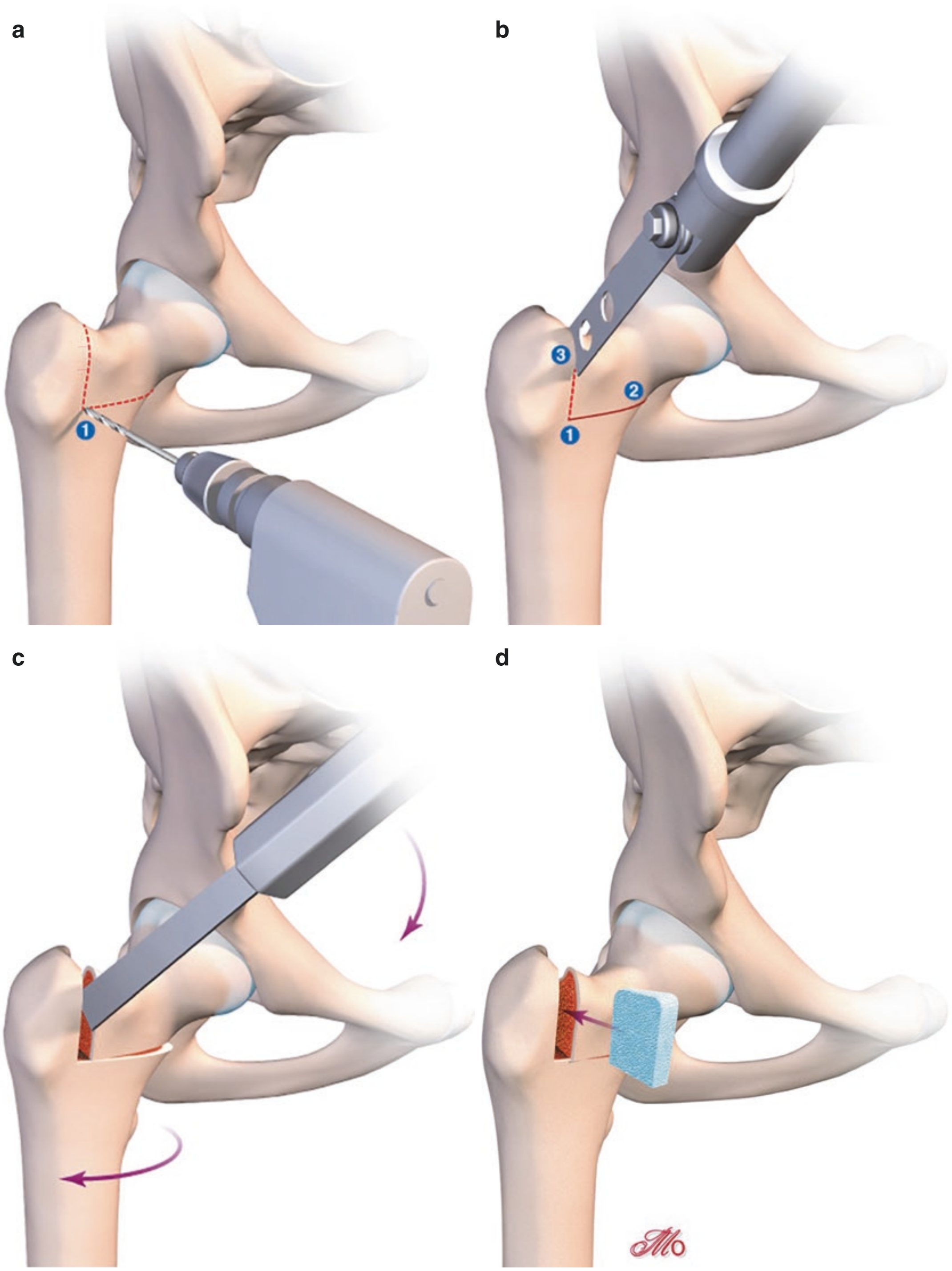

Fig. 13.7 Derotation. (**a**) Using fluoroscopy to locate the junction between the two osteotomy lines. (**b**) The osteotomy line penetrates approximately 1 cm into the anterior cortex. It must not touch the posterior cortex due to the proximity of the median circumflex vessels. (**c**) The limb is placed in medial rotation using the orthopaedic table. A 15/20 mm osteotome is used to hold the neck and epiphysis in medial rotation whilst the orthopaedic table is gently adjusted to produce lateral rotation. This leaves a posterior hinge to protect the median circumflex vessels. (**d**) A lyophilized bone wedge is inserted to produce the desired angle of correction. The bone fragments used for tibial osteotomies usually work very well. (**e**) Fixation using two lateral screws

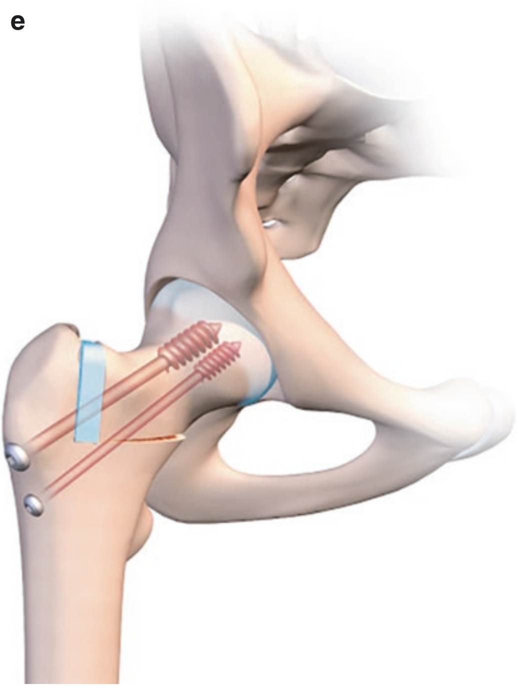

Fig. 13.7 (continued)

we lost some of the correction obtained immediately after the surgery. This was due to an allograft wedge that became impacted and was unable to sustain the correction. Since then, we have changed the way we perform valgus corrections. We now fill the gap using a hydroxyapatite wedge, which is firmer, and then complete the procedure using a fully threaded cannulated screw.

One patient had already undergone several procedures prior to her osteotomy and was given a total hip replacement after 3 years. However, even after the replacement surgery, her Harris score was fairly low.

No patient across the whole series presented any femoral head necrosis.

13.6 Discussion

Femoral osteotomies for correcting varus or valgus deformities and version abnormalities are usually performed using a lateral approach and a plate [16]; derotation osteotomy can also use a superior portal and an intramedullary nail [17].

In both cases, the primary and notable disadvantage is the residual effect on the surrounding muscle tissue. The use of a plate requires avulsion of the vastus lateralis, whereas a nail gets inserted via the gluteal muscles and is accompanied by a loss of intramedullary blood supply due to the reaming.

Since developing this technique a dozen years ago, we no longer see any need to use the old lateral method. This approach is attractive for many reasons, because it is intermuscular, interneural and never implicates the gluteals which are essential for rapid recovery of a fluid gait.

Patient comfort is the primary motivation for this change. It did not take us long to notice the speed of recovery and the fact that patients found it much easier to return weight to the limb.

We were somewhat surprised to see that several patients had almost stopped needing their crutches by the 6-week check-up.

After the traditional lateral surgery, it takes roughly 3 months before patients can again bear weight on the leg, and we have always felt that the recovery time is much longer [16, 18].

As with anterior portal hip replacements, the fact that the gluteal muscles remain intact promotes faster weight-bearing. Our patients now only need to spend one night in hospital, although it could probably also be performed as an outpatient procedure.

However, despite not being particularly difficult, it does require precise technical execution. The osteotomy line must terminate in the greater trochanter for both valgus- and varus-producing osteotomies. If the lateral line, which is a controlled fracture, terminates too high in the femoral neck, there is a probable risk of femoral neck instability. We have encountered this problem just once. Recovery was also slower, and we were unable to authorize weight-bearing until 4 months post-surgery. Nevertheless, there was no fixation instability and the final outcome was satisfactory.

With derotation osteotomies of the femoral neck, the most common technique might cur-

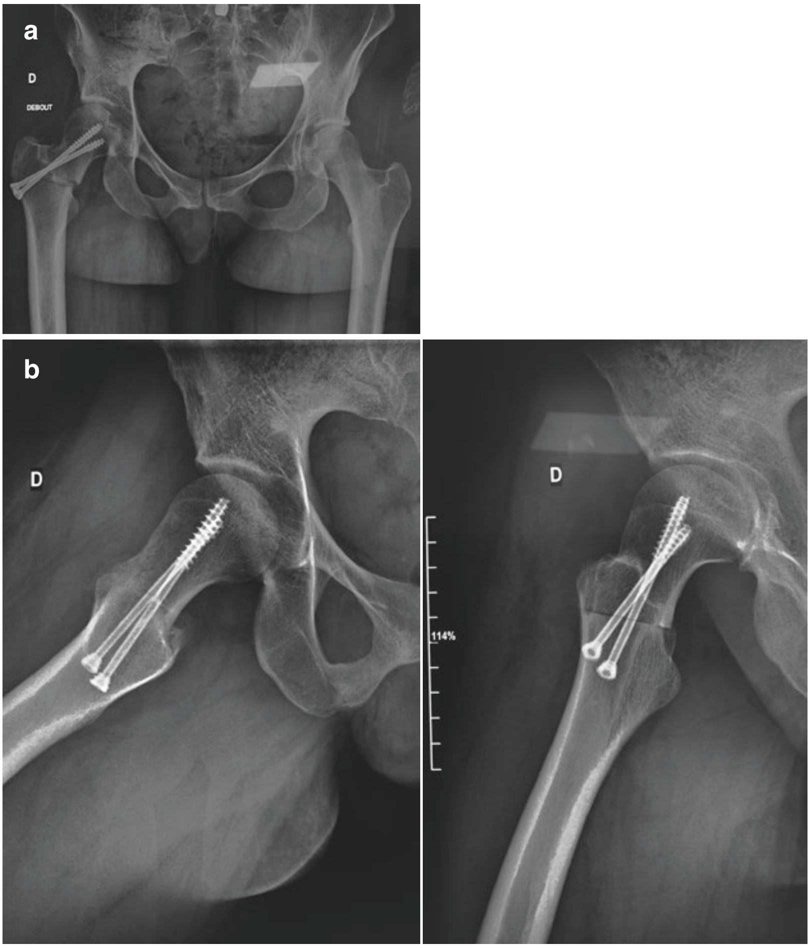

Fig. 13.8 Derotation

rently involve the use of an intramedullary nail and resection of the diaphysis beneath the greater trochanter using an intramedullary saw [17, 19]. This is a reliable and well-documented technique, but one that requires sufficient experience of locked nails and the use of an intramedullary saw. This highly specific instrument is unfortunately not available everywhere; therefore, our solution may be more appropriate.

Another benefit of this technique is that it treats the problem in the exact location of the deformity and does not alter the diaphysis. The intramedullary technique may possibly be better for patients with concomitant problems of the knee, the patella in particular, with our technique being more effective in cases of specific hip-related problems. Finally, both valgus and version correction can be performed simultaneously, something that is obviously quite unthinkable using the intramedullary solution. Removing the intramedullary nail is also a little more complicated than simply removing two screws.

Hip dysplasia is often a multifactorial condition. In some cases, as in our series or that of Buly et al. [19], the femoral osteotomy must be accompanied by an additional surgical procedure such as periacetabular osteotomy, hip arthroscopy or mosaicplasty (Fig. 13.9). In both of the techniques described above, this additional procedure will require additional incisions or portals.

Our technique, however, has the advantage of involving one single small incision through which any additional procedure can also be performed with ease. With a periacetabular osteotomy [20], the scar extends to the iliac crest

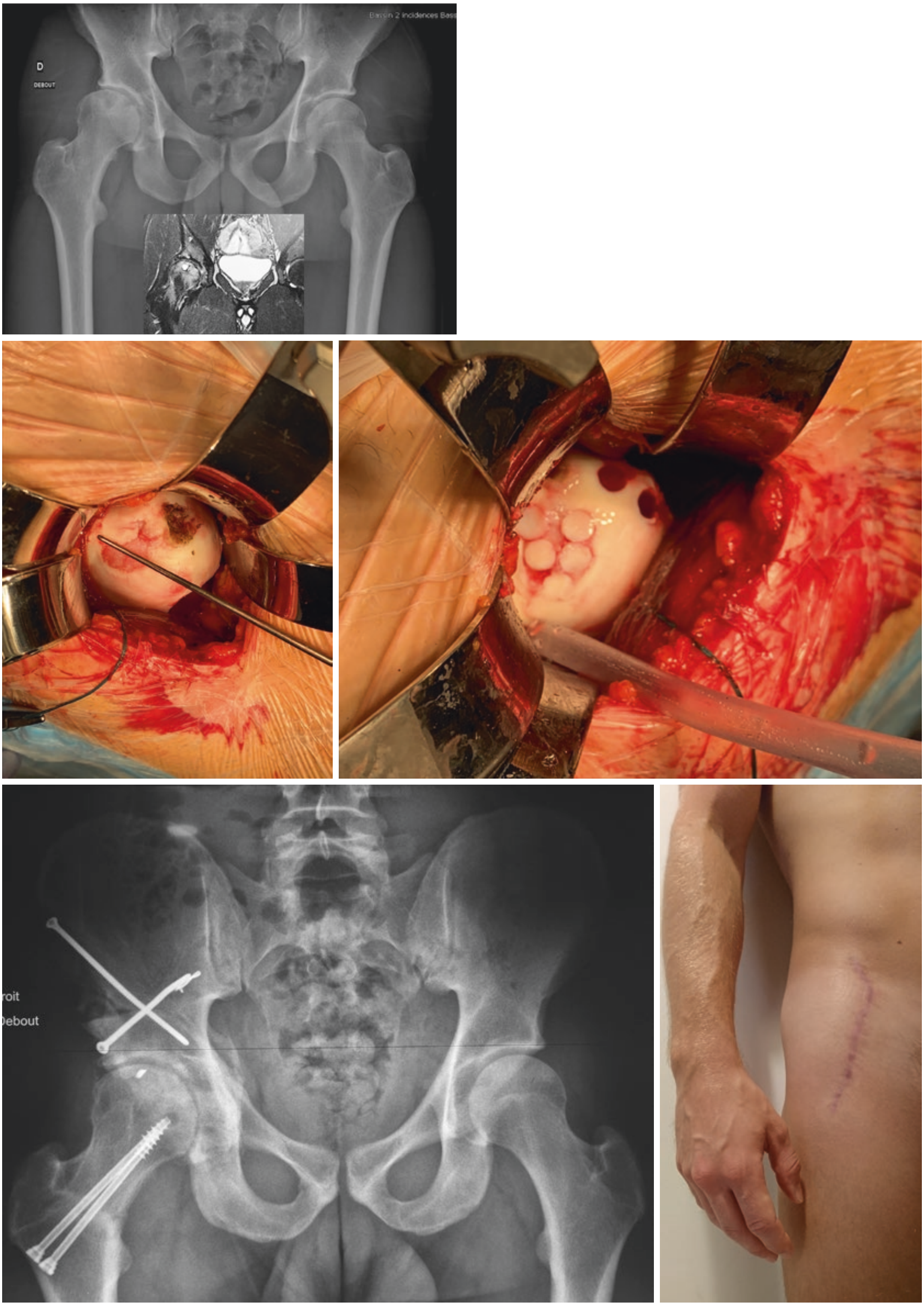

Fig. 13.9 Varization, periacetabular osteotomy + mosaicplasty

with or without avulsion of the anterior superior iliac spine.

We are unable to comment much on blood loss because this issue was not covered by our study; however, once again it is likely that the reduction in soft tissue release equates to less blood loss.

One further benefit of this technique is that the changes to the proximal femur cause fewer problems for patients. The osteotomy line is a little higher than for the traditional technique and has less effect on the overall shape of the femoral metaphysis. The more streamlined fixation material also means that, in theory, there should be no difficulties inserting a femoral implant [8, 13]. Finally, but not least of all, if in the future the patient requires a joint replacement, the surgeon can simply reuse the osteotomy portal, provided of course that he or she is familiar with hip arthroplasty via the anterior approach.

Many surgeons still have doubts over one particular issue, namely, the proximity of the circumflex vessels. The ascending lateral circumflex bundle has only a minimal role in supplying blood to the femoral head. For Dewar et al. [21] the head of femur obtains 82% of its blood supply from the medial circumflex artery, and the neck of femur 67%. Ligation of the lateral circumflex vessels is therefore perfectly safe. Nevertheless, it is crucial that the medial circumflex bundle remains intact. These vessels arrive from the posterior neck, running first across the posterior aspect of the lateral obturator tendon [22, 23]. As they pass through the capsule, they are perfectly visible and they must of course be identified before the osteotomy begins. For varus and valgus correction, there is no risk of damage in this area and the vessels are in principle protected by the lateral obturator and sit well away from the bone. The vertical osteotomy line that we suggest for a derotation osteotomy is much more critical. It should pass well behind, almost into the greater trochanter. Crossing the posterior cortex will not work, since this is where the rotational hinge sits and it will spontaneously break. The risk of necrosis is a false alarm, based on a misunderstanding of the finer anatomical points of the blood supply to the proximal femur. It should be reassuring to know that we have never had any problems with any of our patients.

13.7 Conclusion

Proximal femoral osteotomy is no longer a common procedure. The lengthy recovery period and the success of hip replacement surgery have considerably undermined its value. Nevertheless, in a young osteoarthritis-free adult, it still represents a highly relevant solution.

Moreover, our particular technique is much simpler with a much easier recovery period for our patients. It can even be performed simultaneously to a periacetabular osteotomy, using the same portal.

The surgery requires a thorough technique, but for anyone who regularly carries out hip replacements via the anterior approach, it poses no particular problem. The femoral head is resected in almost exactly the same way as for replacement surgery.

Over a decade of experience using this technique, the consistent results and the absence of any vascular complications mean we offer it to our patients without second thought.

Any surgeon interested in hip salvage surgery should include proximal femoral osteotomy in his box of tricks.

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Part III

Capsulo-Ligamentous

14

Labral Debridement – Repair – Reattachment

Nestor Zurita and Eric Margalet

14.1 Introduction

The importance of the acetabular labrum has been widely studied. The labrum plays an important role in the stability increasing the acetabular surface area and volume of the hip joint. In this line, the labrum acts as a seal, ensuring more constant lubrication of the fluid film within the hip joint. It contributes to the stability of the hip joint due to its valve effect and helps to share the load.

In this context, the labrum plays a fundamental role in the pathological mechanisms of the hip. In fact, the prevalence of labral tears in patients with hip or groin pain is situated from 20% up to 55% [1]. The impact of this pathology is its relationship with degenerative phenomena.

Labral tears can be classified by their location as anterior, posterior, or superior/lateral; by morphology as radial flap, radial fibrillated, longitudinal peripheral, and unstable; or by etiology as trauma, FAI, capsular laxity/hip hypermobility, dysplasia, and degeneration [2].

With respect to histological analysis, labral tears have also been classified in type 1, where labral tear consists of a detachment of the labrum from the articular cartilage surface and occurs at the transition zone between the fibrocartilaginous labrum and the articular hyaline cartilage. This type of tear is perpendicular to the articular surface and, in some cases, extends down to the subchondral bone. In type 2, labral tear consists of one or more cleavage planes of variable depth within the substance of the labrum and extends perpendicular to the surface of the labrum [2, 3].

The most common of all the lesions of the labrum is an anterior labral tear associated with an anterior acetabular chondral injury [4]. The reason for the prevalence of anterior labral tears is that this region is subjected to higher forces or greater stress than other regions of the labrum.

The clinical presentation is an anterior hip and groin pain and occurs more often in women than in men. Pain may radiate to the knee. Data suggest that anterior hip or groin pain is more consistent with an anterior labral tear, whereas buttock pain is more consistent with a posterior labral tear [5].

Walking, pivoting, prolonged sitting, and impact activities, such as running, often aggravate symptoms, and it can equally be associated with other symptoms such as night pain [6]. Functional limitations are limping, needing a banister to climb stairs, limitation of walking distance, and sitting limited to 30 min [7].

The most consistent physical examination finding in patients with acetabular labral tears is a positive anterior hip-impingement test [6, 7]. The

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hip rotation is the main limitation of ROM, although in many cases, the patients can be associated with limitations in hip flexion, adduction, and abduction [2].

Diagnostic imaging usually begins with a radiographic evaluation with special attention to structural abnormalities of the hip and pelvis. However, magnetic resonance arthrography (MRA) is the best test for the diagnosis of labral lesions [6]. An MRA is also useful to rule out other abnormalities of this pathology that include stress fractures, neoplasm, avascular necrosis, osteitis pubis, synovitis, ligamentum teres rupture, and other extra-articular soft tissue abnormalities, such as sports hernias and tendon avulsions [8].

Diagnostic-image-guided intra-articular hip injections can also be helpful in the diagnosis of labral tears [8].

Arthroscopy, which is considered the gold standard, can be a diagnostic and therapeutic medium.

14.2 Positioning and Anesthesia

General or spinal anesthesia plays the main role to obtain optimal muscle relaxation in order to minimize the amount of traction needed for distraction [2].

The procedure can be performed by either a supine, lateral, or modified supine approach. Our preference in the treatment of labral tears is in the supine position on the orthopedic traction bed with the operative limb in five degrees adduction, five degrees flexion, and internal rotation dialed to the degree of femoral anteversion. An oversized peroneal padded post is used to minimize pudendal nerve injury, and the feet are also well-padded (Fig. 14.1).

14.3 Portals

In the classic approach to the hip, an anterolateral portal (AL) is established using a spinal needle localization entering the joint under radioscopic control. The 70-degree arthroscope is introduced into the joint. A syringe of air may be injected through the arthroscope and this will frequently clear the field of view to visualize the anterior triangle, optimizing modified mid-anterior portal (MMAP) placement with spinal needle localization [9] (Fig. 14.2).

Fig. 14.1 Supine position on the orthopedic traction bed

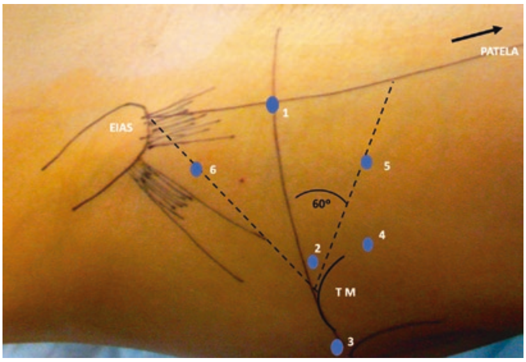

Fig. 14.2 Portals of the classic approach: (1) Anterior Portal (AP), (2) Anterolateral portal (AL), (3) Posterolateral portal (PL), (4) Distal anterolateral accessory portal (DALA), (5) Mid-anterior portal (MAP), (6) Proximal mid-anterior portal (PMAP)

The outside-in approach recreates an open anterior approach to the hip. It begins by creating a precapsular virtual space triangulating with two blunt elements, such as the arthroscope sheath with its obturator and a Wissinger stem [10]. This approach can be carried out through the use of classic portals [11], although there are specific portals for it (Fig. 14.3) [10].

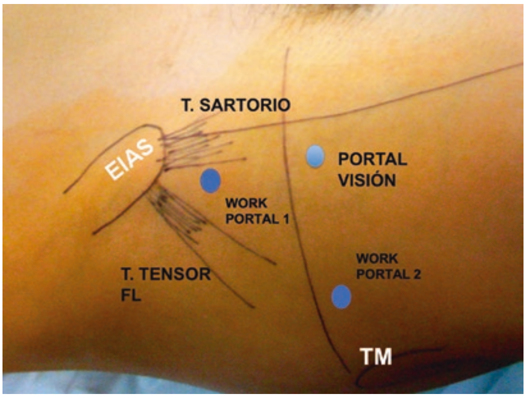

Fig. 14.3 Specific portal of the outside-in approach

No differences have been found in outcomes regardless of the access used. Classic access seems to offer a higher postoperative range of motion and lower risk of heterotopic ossifications. Nevertheless, the outside-in approach does not need specific instrumentation, it reduces the traction time and has less risk of labral and chondral damage compared with classic access. Finally, highlight that technically could be easier because, among others, it allows the use of the 30 degrees arthroscope [12].

Tips and Tricks

- To establish the anteromedial portal using a spinal needle, it will be helpful to use radioscopy continuously to follow the path of the needle and facilitate the arrival to the intra-articular compartment of the hip.
- Air can be injected from a syringe through the needle to confirm with radioscopy that we are well-positioned in the intra-articular compartment.

14.4 Capsulotomy

In the classic approach, the interportal capsulotomy should be as far away as possible from acetabulum and labrum to optimize the amount of tissue available for capsular repair at the end of the surgery [9].

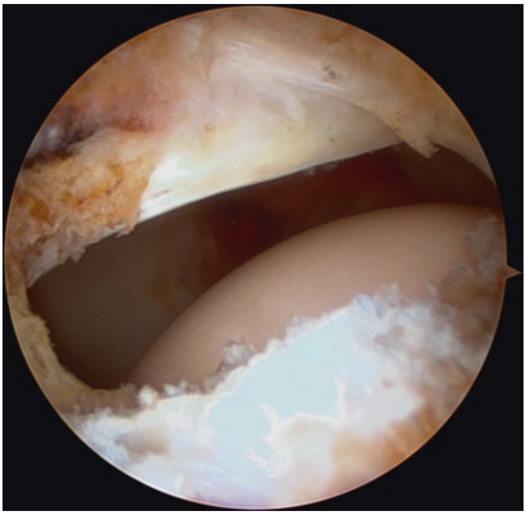

Fig. 14.4 Transverse branch of the capsulotomy

With an outside-in access, the approach crosses the intermuscular plane between the sartorius and the tensor of the fascia lata. In this technique, the peripheral compartment is first accessed. After the precapsular fatty tissue is cleaned, a capsulotomy is performed. The actual line is limiting the capsulotomy to the transverse branch of the capsule to be as conservative as possible to maintain the stabilizing function of the iliofemoral ligament (Fig. 14.4) [13]. To work in the peripheral compartment is enough elevating or retracting the capsule. Labral fibers are perpendicular to those of the capsule, which is pearly white and easily identifiable.

Through the use of transcapsular sutures and/or anchors, it can be closed after work in the peripheral compartment [11].

Tips and Tricks

- In order not to lose the location and orientation of the portals, we can use hemi cannulas that allow us to change working instruments quickly and reliably.

14.5 Labral Debridement

Arthroscopic debridement may be an effective treatment for labral tears, but it has shown inferior results compared to labrum repair. Therefore,

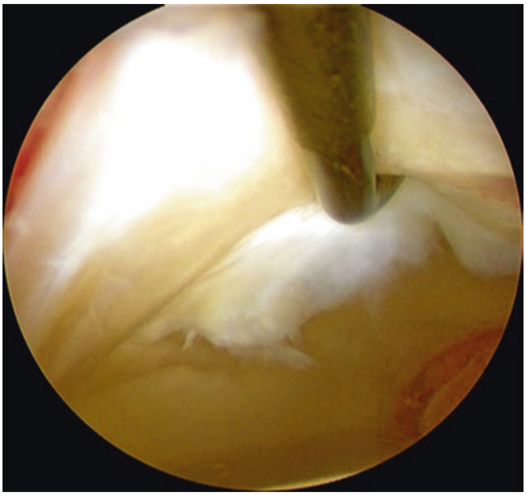

Fig. 14.5 Stable labral tear

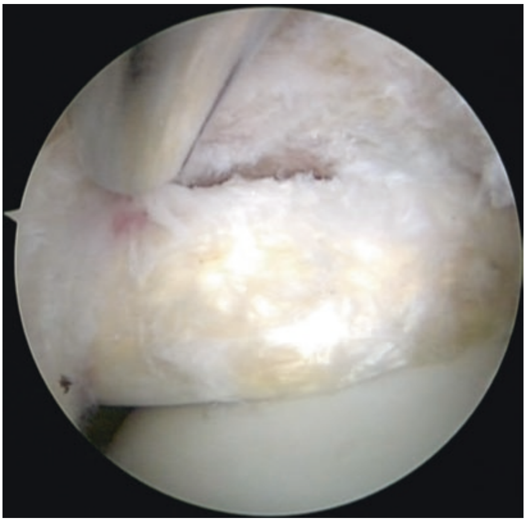

Fig. 14.6 Decortication of the acetabular rim

the role of labrum debridement has been unclear. In selected cases of stable labral tears (Fig. 14.5), the labral debridement can allow a functional labrum. In these cases, the outcomes of labral debridement produce favorable results comparable with a labral repair [14].

14.6 Labrum Repair

To obtain good labrum repair, the most important is to prepare it based on preoperative imaging and intraoperative decision-making. An appropriate decortication acetabuloplasty of the rim is performed by preparing a bleeding surface for labral healing in the bony rim (Fig. 14.6). Depending on the magnitude of the rim resection, the labrum does not necessarily need to be detached [15]. After knowing the characteristics of the tear, the repair may begin [9].

The vision portal in the outside-in access is located at the cutoff point between the line joining the greater trochanter and the line that goes from the anterior superior iliac spine to the kneecap, location similar to the AP, while the work portal is located about 4–5 cm distal and 2 cm lateral to this line. In this context, in the classic approach, the addition of a distal anterolateral accessory portal (DALA), approximately 4 cm distal to and in line with the AL portal, provides an optimal angle for anchor placement.

The use of cannulas facilitates the work through the portal, besides to allow the introduction of the anchors and the necessary material to perform the suture. The number of anchors depends on the labrum tear size. Regardless of the portal used, the anchor should be placed as close as possible to the rim so that when knot-tying, the labrum is not pulled over the rim, altering the normal anatomy. In addition, the angle must ensure that the drill bit and/or anchor does not penetrate the subchondral bone and/or articular cartilage (Fig. 14.7). Finally, the angle placement of the anterior anchor must ensure that the psoas tunnel is not perforated. If any of the previously described circumstances occurs, the result of the surgery may not be satisfactory and the symptoms may persist [9].

The safety margin for anchor placement has been well defined using the acetabular rim angle [16]. This angle is made by the subchondral margin and the outer acetabular cortex. This angle shows how much room exists to place a suture anchor completely in the bone. The rim trimming increases the rim angle, but if the drill depth increases, the rim angle decreases. The addition of curved drill guides and curved anchors prevent iatrogenic articular penetration [17].

After the placement of the anchor, the suture configuration should be selected. If we compare looped versus pierced suture techniques for labral repair, the results are statistically and clinically

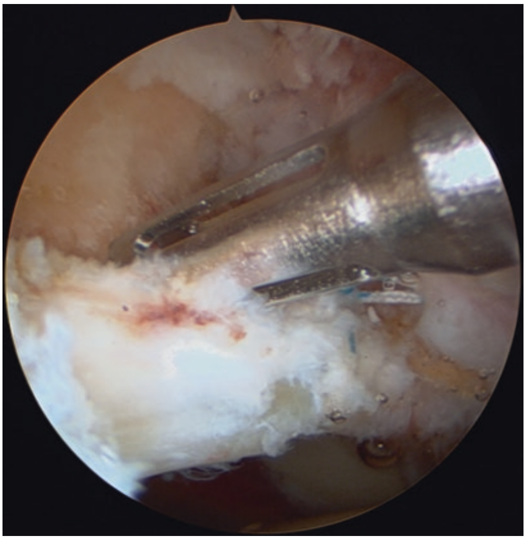

Fig. 14.7 Adequate anchor placement

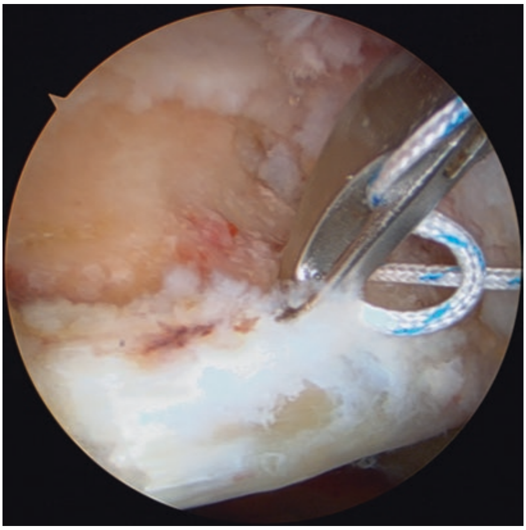

Fig. 14.8 Labrum pierced by the penetrator grabber

similar and there are no significant differences in revision or failure rates [18].

The systematic looped suture would be as follows: once the anchor is placed on the acetabular rim, the base of the labrum is pierced with a direct suture penetrator grabber with a maximum angle of 25°, previously taking one of the anchor threads (Fig. 14.8).

At this moment, it visualizes the interior of the joint, where the tip of the penetrator grabbed is observed with the thread that it has transported to the intra-articular space (Fig. 14.9).

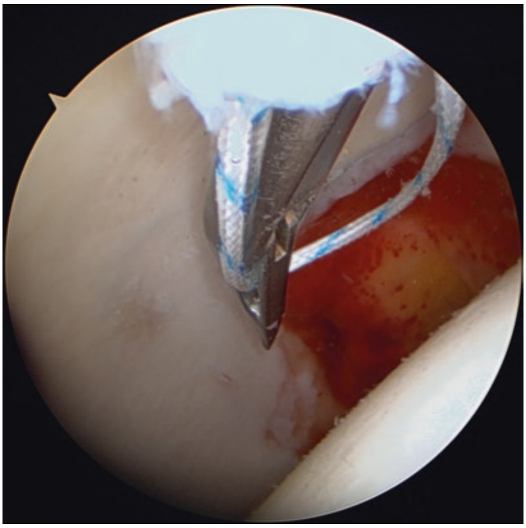

Fig. 14.9 Visualization of the interior of the joint

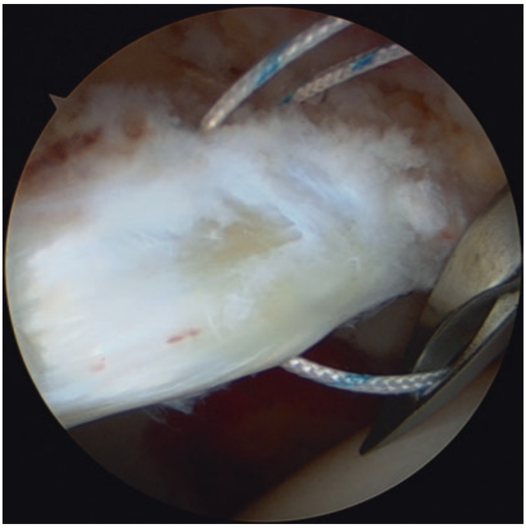

Fig. 14.10 Recovering the anchor thread transported by the penetrator grabber

The next step consists in recovering the penetrator grabbed by the cannula of the work portal, leaving the anchor wire in the central compartment. The penetrator grabber has been inserted again through the work portal toward the space between the labrum and the femoral head formed as a result of the traction maintained on the limb with the goal of recovering the anchor thread transported by the penetrator grabber in the previous step (Fig. 14.10).

Already, with both ends of the suture in the work portal, the process of knotting begins. It is

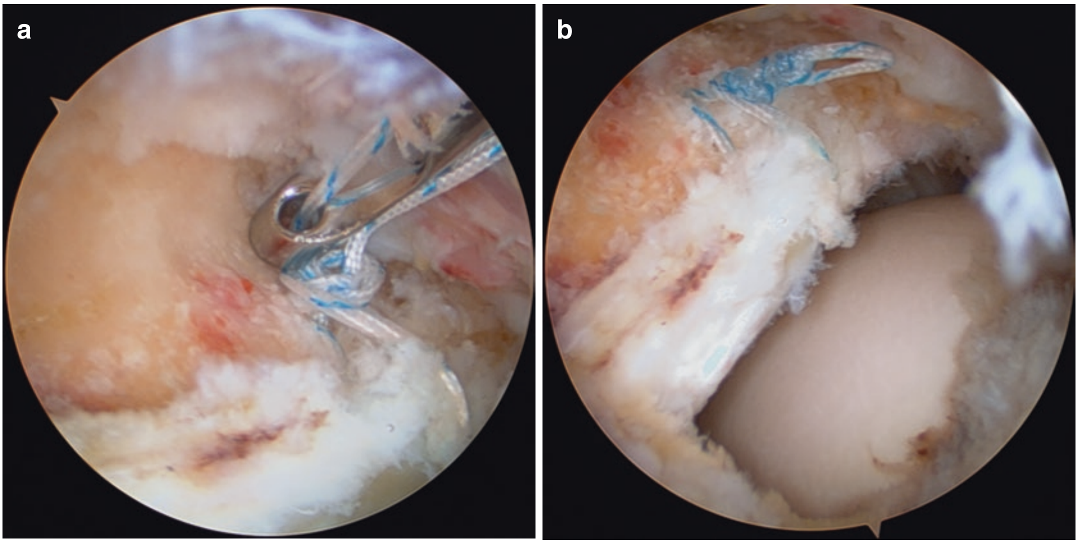

Fig. 14.11 (**a**, **b**) Labrum knotting process

interesting to note that in the case of hip arthroscopy and unlike what happens in the shoulder, the thread used as a post is the strand of the anchor that does not go through the tissue to be sutured. This allows to place the knot outside the joint avoiding any iatrogenic situation derived from a bad placement of the knot (Fig. 14.11a, b).

To perform a pierced suture, the systematic approach is similar to the one described above. The difference is, when retrieving the anchor wire transported to the interior of the joint, it is done by transferring the base of the labrum with the penetrator grabber or specific material destined for this purpose.

Labrum repair has consistently shown better subjective results in patients compared with debridement. Labrum repair also obtained better postoperative results compared to debridement [19].

Tips and Tricks

- To perform the suture of the labrum, we must choose as a work portal, the one located more perpendicular to the rupture of the labrum to be sutured because it facilitates the placement of anchors and the handling of the threads.
- The use of cannulas facilitates work through the portal. The technical difficulty in placing them decreases if we use cannulated introducers through Wissinger stem.

14.7 Conclusion

The acetabular labrum plays an important role in the hip. In this context, the labrum plays a fundamental role in the pathological mechanisms of the hip. Therefore, the role of arthroscopy in the treatment of labral tears is highlighted. To obtain good labrum repair, it is important to prepare based on preoperative imaging and intraoperative decision-making. You have to keep in mind that the outcomes obtained from hip arthroscopy do not depend on the approach system used. In this context, the actual line is limiting the capsulotomy to be as conservative as possible to maintain the stabilizing function of the iliofemoral ligament. Arthroscopic debridement may be an effective treatment for labral tears, but it has shown inferior results compared to labrum repair. With respect to the suture configuration, if we compare looped versus pierced suture techniques for labral repair, the results are statistically and clinically similar and there are no significant differences in revision or failure rates.

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Labral Reconstruction

15

A. J. Andrade

15.1 Introduction

The labrum is a fibrocartilaginous structure made of alternating layers of type I collagen and hyaline cartilage matrix orientated in the direction of functional stress.

There are three layers to the labrum:

- **A basal surface** that connects the labrum to the acetabular bony rim.
- **An internal** articular surface continuous with the acetabular articular surface.
- **An external** surface in continuity with the capsule.

The functions of the labrum are as follows:

- **To improve hip joint stability—**by deepening the socket and partially sealing the joint to create a negative intra-articular pressure. Creates the '**Fluid seal**'.
- **To increase joint congruity**—and reduces contact pressure so that frictional forces increase when the labrum is removed.

The blood supply to the labrum is from a periacetabular vascular ring formed by the superior and inferior gluteal arteries.

Labral tears are most commonly seen in the setting of femoroacetabular impingement, but can be seen with any condition affecting the hip.

15.2 Labral Repair

Labral repairs were first described by Ganz as part of the open surgical dislocation procedure he described [1, 2], and later arthroscopic techniques were popularised by Philippon [3–5].

When considering which particular technique to employ when carrying out labral repair, the shape of the labrum, the condition of the labrum and the age of the patient should be considered. Knotless and knotted anchors have been used, and there are no reported differences in outcome [6]. Similarly, there have been no reported differences between looped suture fixation and pierced suture techniques [7].

Labral repair has been shown to be an effective treatment option that leads to a greater improvement in pain, function and return to activity, particularly when compared with resection or debridement [8].

The success of labral repair does however depend on **addressing any underlying anatomical condition**, good surgical technique and having a well-motivated patient who undergoes a phased rehabilitation programme.

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15.3 Labral Reconstruction

There are however certain situations in which labral repair may be less effective:

- Where labral damage is too severe (complex tear with degeneration, ossified or segmental deficiency).
- When the labrum is too large (>10 mm).
- When the labrum is too diminutive (<3 mm).

In these situations, and also **when labral repair has failed** for whatever reason, labral reconstruction has been proposed as a means of restoring the integrity of the chondrolabral junction.

The distribution of **nociceptive innervation in the labrum** and the presence of the free nerve endings and nerve end organs predominantly on the articular side of the labrum [9, 10] help to explain one of the theories of how the labrum can act as a pain generator. Retaining the labrum with labral repair therefore can lead to retention of the pain generator, with resultant ongoing pain. In contrast, labral debridement or resection can therefore in this way result in pain resolution.

Labral reconstruction, where the pain generator is resected and replaced with a graft, has the distinct advantage of then also restoring the function of the labrum and chondrolabral junction. This restores the fluid seal and provides improvements in stability, and reduction in hip contact pressures resulting in successful outcomes from labral reconstruction.

Sierra and Trousdale first reported a technique for reconstruction of segmental labral defects via a **surgical hip dislocation** using a ligamentum teres autograft [11]. Philippon first reported on an **arthroscopic technique** for labral reconstruction using an iliotibial band autograft [12, 13]. Matsuda reported on labral reconstruction using a gracilis autograft [14]. Since then, other arthroscopic and open techniques for labral reconstruction using a variety of different autograft and allograft tissues have been reported with good outcomes [15–20].

Labral reconstruction has provided patients with significant improvements in pain reduction, function, return to sports, avoidance of future hip arthroplasty and high levels of satisfaction [21–23].

Augmentation of the labrum is proposed by some as an alternative to reconstruction, and the results of this technique are also encouraging [24]. One advantage of this technique is that the labrum is not resected, and so allows direct suturing of the graft to the native labrum, with good to excellent reported outcomes [25].

The choice of graft for reconstruction or augmentation remains a subject of some debate [26, 27]. Some authors prefer autograft and others prefer allograft. There is even potentially a role for a synthetic graft (xenograft), which may be more affordable and could even come pre-prepared in predetermined diameters and lengths. A potential advantage of a xenograft is that it may improve integration and speed up the period of labralisation (that every graft undergoes), by reducing the time needed for remodelling [28]. Further research is required to establish what the ideal graft material is.

In the vast majority of cases, labral reconstruction is carried out in the revision setting [23]. Some authors have however popularised the use of primary labral reconstruction with very encouraging results [29, 30].

There have been three systematic reviews on labral reconstruction published in 2019 alone, with the most recent in October 2019 [31–33], and all of these, as well as two previous systematic reviews [34, 35], have concluded that acetabular labral reconstruction achieves clinically significant functional improvements with low complication rates, low rates of revision surgery and low progression rates for osteoarthritis.

15.4 Complications

Labral reconstruction is a complex procedure that is technically very difficult, requiring high skill levels in arthroscopic surgery.

Concerns can be raised with regard to prolonged traction time, particularly in the early stages of the learning curve. Furthermore, there can be difficulties with the introduction and fixation of the graft, as well as the risk of iatrogenic injury during the procedure.

Overall, however, the literature reports a low complication rate with this procedure.

15.5 The Author's Preferred Technique of Labral Reconstruction

15.5.1 Introduction

The author initially gained experience with segmental fascia lata **autograft** labral reconstruction, but due to issues with the handling properties of the autograft tissue then changed to fascia lata **allograft** for segmental labral reconstruction (Fig. 15.1).

An observation in common with others was that segmental reconstructions necessitated anastomoses with host labrum at each end of the graft (i.e. two anastomoses), and these can be weak points of the reconstruction. With ever-increasing length of reconstructions, the need for one or both anastomoses can be abolished, as the graft can then potentially be secured low on the acetabular clockface and close to or confluent with the transverse acetabular ligament.

Fig. 15.1 Fascia lata allograft (freeze-dried)

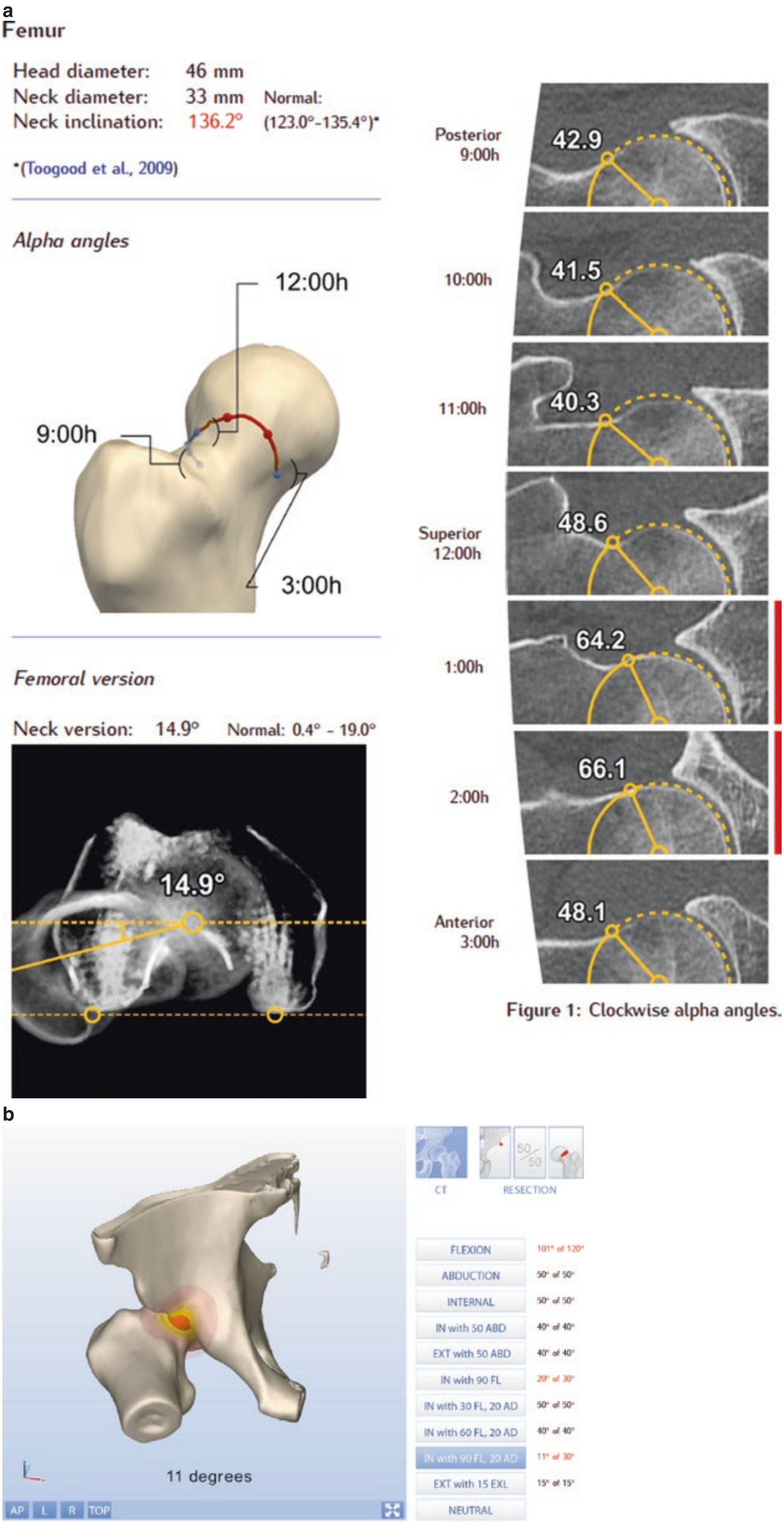
Circumferential acetabular labrum reconstruction is now growing in popularity and is even being proposed as a primary procedure [29, 30].

15.5.2 Pre-operative Considerations

In the vast majority of cases, the author carries out labral reconstruction in the setting of revision surgery. It is therefore essential to eliminate other causes for ongoing pain in this setting.

1. **Imaging studies** are needed to exclude dysplasia or other developmental abnormalities. Radiographs need to show a joint space of at least 2 mm and a femoral head–neck offset that is either already normal or that can be restored to normal with further surgery. If the femoral head–neck offset has been compromised by over-resection of the cam lesion, then labral reconstruction would be contraindicated.
2. If there is any doubt from the radiographs, then computed tomography (CT) would be indicated with 3D volume rendering to aid surgical planning. With CT, 3D motion simulation reports (by, for example, Clinical Graphics) can be obtained (Fig. 15.2), which further add value and can provide accurate assessments of radiographic indices.
3. The rotational profile needs to be assessed, at least clinically, and if there is any doubt, a formal CT rotational profile assessment (looking at hips, knees and ankles) is carried out (Fig. 15.3). A rotational profile within normal limits (for acetabular, femoral and tibial rotation) is required for successful labral reconstruction.
4. Magnetic resonance imaging (MRI) can provide information on the integrity of the ligamentum teres, and it is essential that the ligamentum teres is intact if reconstruction is to be successful. Otherwise, consideration might need to be given to reconstruction of both the ligamentum teres and labrum at the

Fig. 15.2 Illustrative example of Clinical Graphics analysis: (**a**) Femoral analysis showing the clockwise alpha angles and femoral anteversion; (**b**) calculated impingement analysis in different positions; (**c**) acetabular analysis showing centre edge angles and acetabular coverage values



Femur

Head diameter: 46 mm
Neck diameter: 33 mm Normal:
Neck inclination: 136.2° (123.0°–135.4°)*

*(Toogood et al., 2009)

Alpha angles

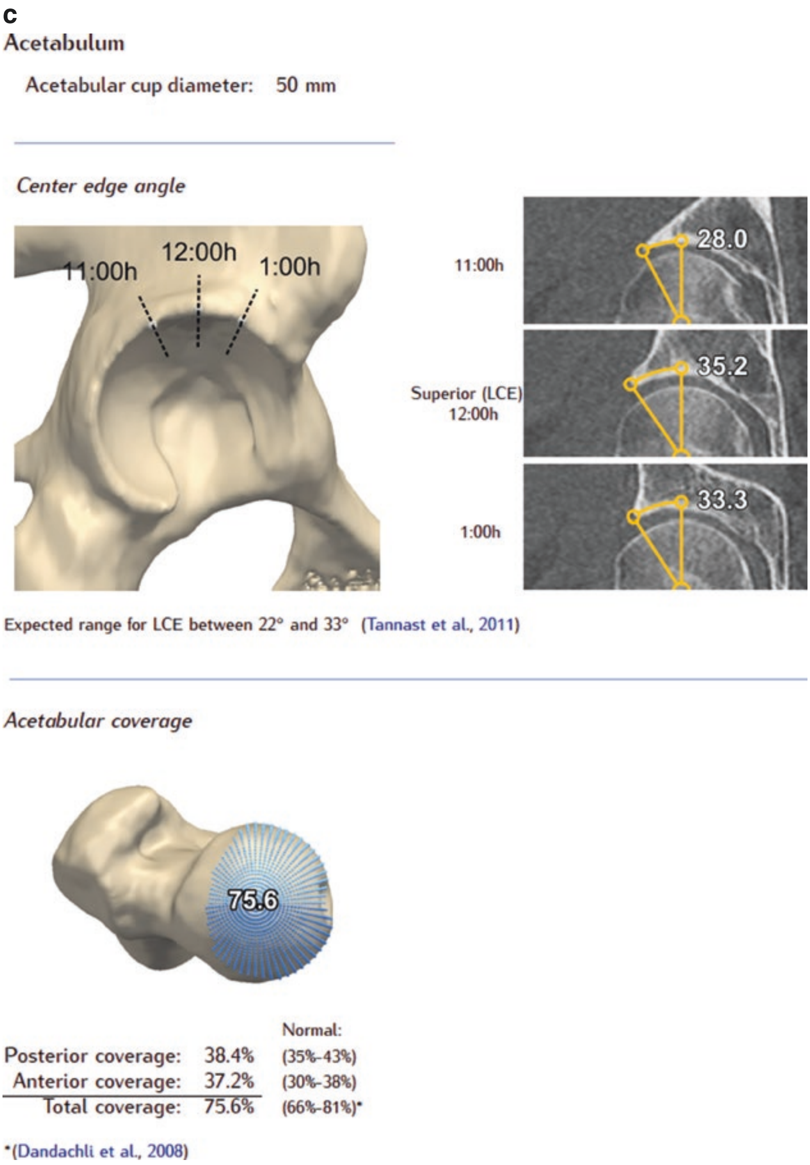
Femoral version

Neck version: 14.9° Normal: 0.4° - 19.0°

Figure 1: Clockwise alpha angles.

FLEXION	101° of 120°
ABDUCTION	50° of 50°
INTERNAL	50° of 50°
IN with 50 ABD	40° of 40°
EXT with 50 ABD	40° of 40°
IN with 90 FL	20° of 30°
IN with 30 FL, 20 AD	50° of 50°
IN with 60 FL, 20 AD	40° of 40°
IN with 90 FL, 20 AD	11° of 30°
EXT with 15 EXL	15° of 15°
NEUTRAL	

Fig. 15.2 (continued)



		Normal:
Posterior coverage:	38.4%	(35%-43%)
Anterior coverage:	37.2%	(30%-38%)
Total coverage:	75.6%	(66%-81%)*

same sitting [36]. MRI will also provide information on the integrity of the articular surfaces of the acetabulum and femoral head. Any significant degenerative change would also be a contraindication to labral reconstruction.

15.5.3 Operative Set-Up and Procedure

1. The patient is **supine** on a **specialist distractor (Smith & Nephew),** under general anaesthesia with muscle paralysis. Antibiotic prophylaxis is given, and the patient is risk assessed for venous thromboembolic prophylaxis.
2. **Hip arthroscopy is started with** the normal two-portal technique (anterolateral and anterior portals) to visualise the joint and carry out the central compartment diagnostic round to identify the full extent of the pathology within the joint (Fig. 15.4).
3. The diagnostic round of the central compartment has to establish the following **triad for**

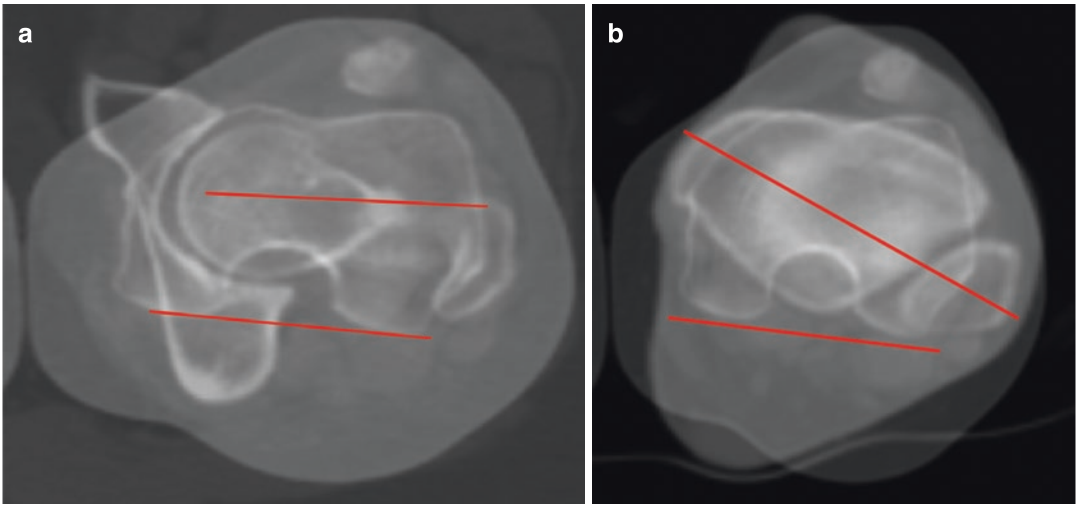


Fig. 15.3 Illustrative example of CT rotational profile assessment: (**a**) femoral version of −1° showing that femoral anteverting derotation osteotomy is indicated prior to considering labral reconstruction; (**b**) tibial torsion of 27° which is within the normal range

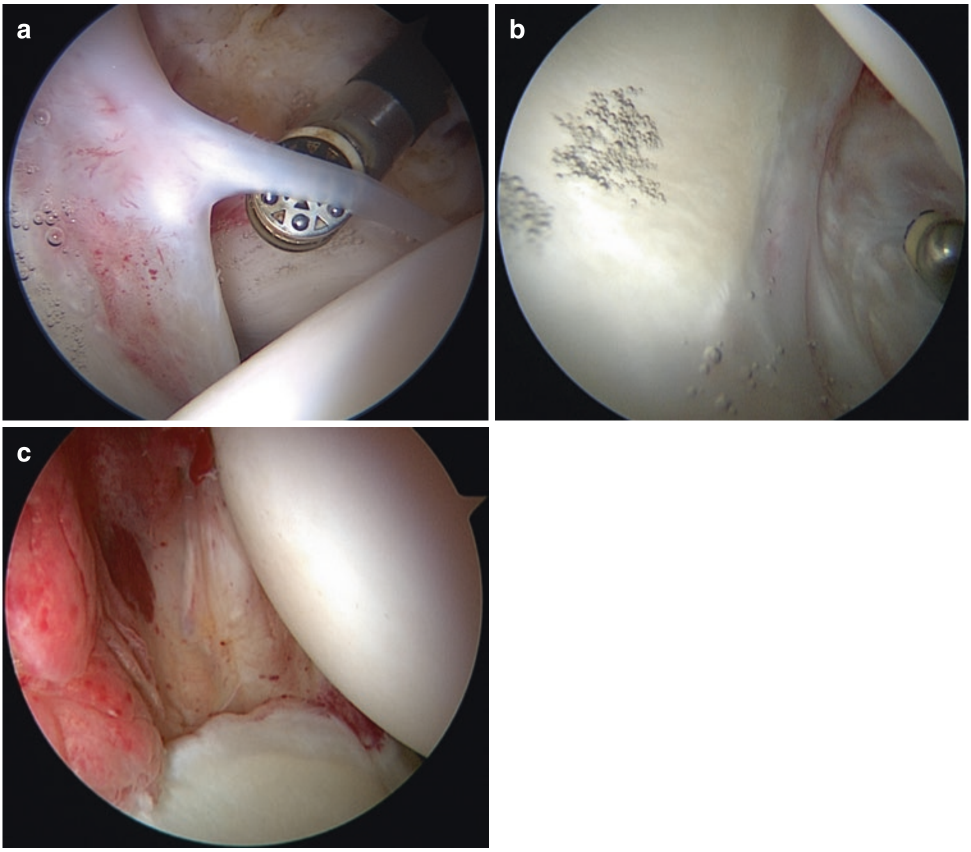


Fig. 15.4 Arthroscopic images obtained during the diagnostic round of central compartment: (**a**) anterior capsulolabral adhesion with inflammation of chondrolabral junction viewed from anterolateral portal in a right hip; (**b**) normal acetabular articular cartilage viewed from anterior portal in a right hip; (**c**) intact posterior bundle of ligamentum teres with leg in external rotation and viewed from anterolateral portal in a right hip

labral reconstruction to be appropriate:
   (a) **Labral damage** is too severe to allow for successful labral repair.
   (b) **Ligamentum teres** must be intact.
   (c) **Articular surfaces** of acetabulum and femoral head must be well preserved.
4. Excise the abnormal labrum and size the defect to determine whether a segmental graft is appropriate or whether a circumferential graft would be preferable. Historically, segmental grafts were the norm, but this technique relies on two graft-host anastomoses. It has, therefore, become preferable to carry out an increasingly circumferential reconstruction, where anastomoses are not needed.
5. At this stage consider whether a **three- or four-portal** technique (distal anterolateral accessory (DALA) +/− posterolateral portals) is required, depending on how extensive a reconstruction is being carried out. For smaller segmental reconstructions can even manage with a two-portal technique, but for a full circumferential reconstruction, a four-portal technique is recommended. Establish the accessory portals as required and consider the use of an appropriate portal saver to facilitate the use of the portals (Fig. 15.5).
6. Carry out a labral resection/debridement and an appropriate acetabular rim trim back to the normal chondrolabral junction as seen from the articular side (Fig. 15.6). In so doing be careful not to create an iatrogenic dysplasia.
7. **Pre-drill anchors** from the appropriate portal. The most anterior and anteroinferior anchors will be drilled and placed through the anterior portal (Fig. 15.7a). The DALA will be used for the more superior anchors (Fig. 15.7b), and then the anterolateral and posterolateral portals for the more posterior anchors (Fig. 15.7c). Consider the need for **all-suture** anchors for the most anteroinferior and most posteroinferior sites, and **Knotless** for majority of clockface (**Speedlock—Smith & Nephew**).
8. An all-suture anchor (Q-Fix) is used at the most anteroinferior (inferior to psoas notch and adjacent to anterior end of transverse acetabular ligament) and most posteroinferior limits of the reconstruction, and the sutures are brought out of the anterior and most posterior portals accordingly.
9. **Prepare the appropriate graft** on back table (the author's preference is to use an allograft fascia lata graft).

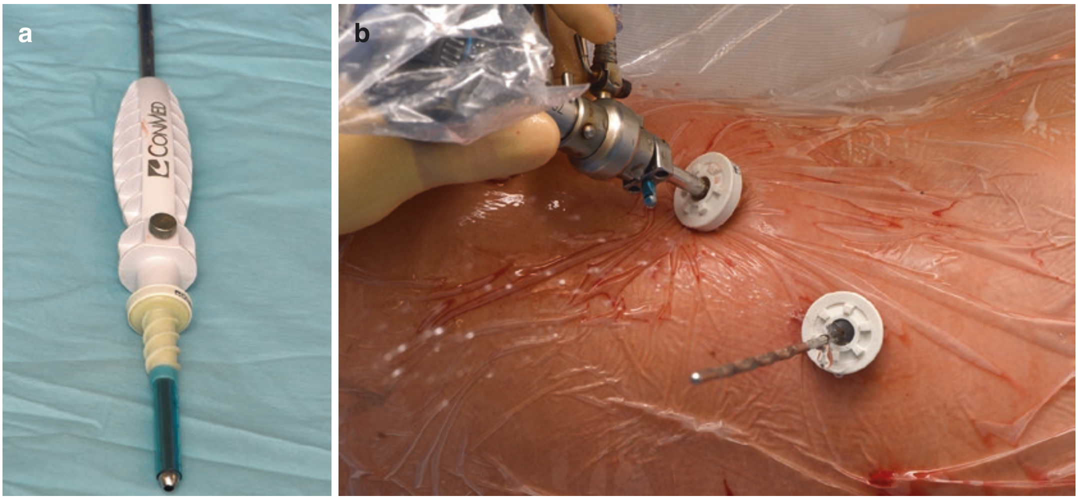


Fig. 15.5 Portal saver (EZ switch, Conmed): (**a**) EZ switch portal saver cut to size and mounted on introducer; (**b**) two EZ switch portal savers in use during a left hip arthroscopy

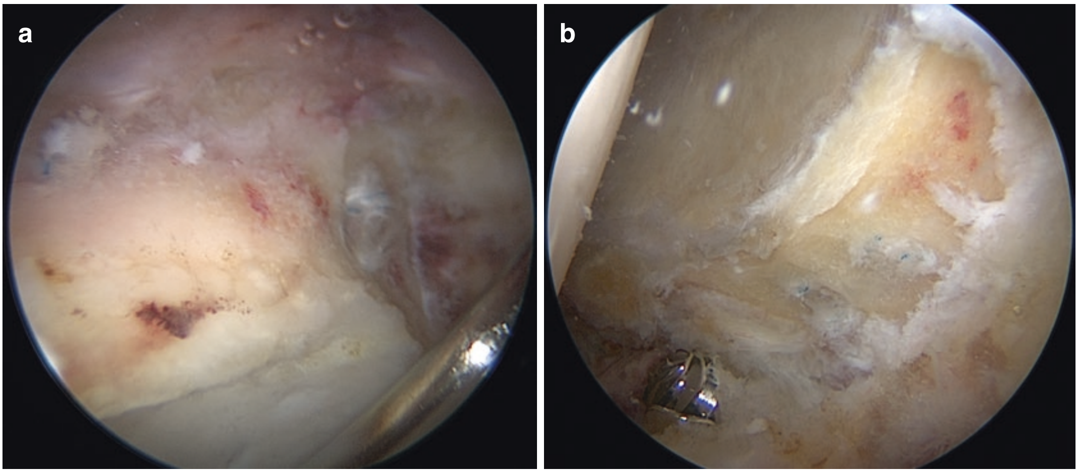


Fig. 15.6 Labral debridement and acetabular rim trim in preparation for labral reconstruction: (**a**) anterosuperior acetabular rim trim and labral debridement viewed from anterolateral portal in a right hip; (**b**) posterior acetabular rim viewed from anterior portal

  (a) Tubularise and whipstitch with an absorbable suture (2/0 vicryl undyed) (Fig. 15.8).
  (b) Mark each end with a different colour suture (to aid identification in joint).

10. The author's preference is to use an all-suture knotted anchor (Q-Fix) for the anterior and anteroinferior zones where the bone is at a premium, and then a knotless anchor (Speedlock) for the superior zones where the bone is more plentiful. Posteriorly again the all-suture knotted anchor (Q-Fix) is used.
11. Bring one end of the suture from the most anterior Q-Fix suture out through the DALA portal and pass this through the anterior end of the graft. This will allow it to be shuttled into the joint. Pass the graft into the joint through the DALA portal (Fig. 15.9) and position the posterior end posteriorly in the acetabulum and pull the posterior stay suture out through the most posterior portal. This allows tension to be applied on the graft for better visualisation of the graft.
12. Take the front end of the graft anteroinferiorly and gather the Q-Fix suture (that had previously been pulled out through the DALA portal) and pull it back out of the anterior portal. This then allows the most anteroinferior anchor to be tied down securing the anterior end of the graft (Fig. 15.10).
13. Then in sequence, secure the graft from anterior to posterior using each anchor that had been pre-drilled (Fig. 15.11). Once the most posterior limit is reached, then secure the posterior end with the most posteroinferior Q-Fix anchor (Fig. 15.12) and cut off any excess length of graft using either a blade or an Eflex ligament chisel.
14. Test the stability of the reconstruction with a hook, and also test that the fluid seal is restored by letting off traction and inspecting the seal throughout (Fig. 15.13).

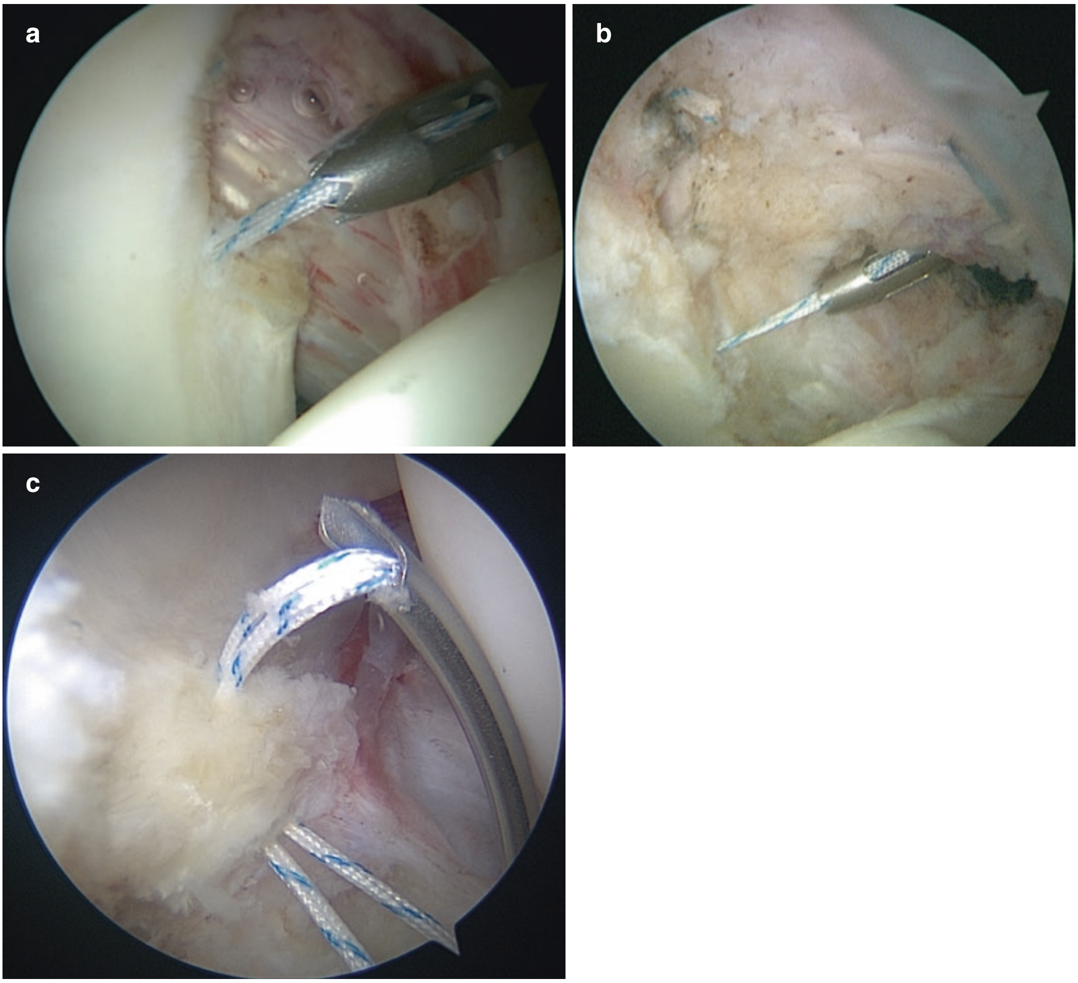


Fig. 15.7 (**a**) Anterior all-suture anchor drilled through anterior portal, at the level of the psoas notch (notice the psoas tendon just behind) as viewed from anterolateral portal in a right hip. (**b**) Superior anchors drilled through distal anterolateral accessory (DALA) portal—note an all-suture anchor in place and to its left the drill hole for a Speedlock anchor (knotless peak anchor). (**c**) Ultrabraid suture being passed around the stump of the native labrum posteriorly in preparation for a Speedlock anchor (as viewed from anterior portal in a right hip)

15. Carry out a dynamic impingement test to ensure satisfactory femoral head–neck offset and contour. Carry out a femoral osteoplasty as necessary to optimise both the contour and the offset (Fig. 15.14).

15.6 Further Considerations

Techniques of labral reconstruction continue to be refined. Continuing developments in instrumentation will inevitably turn what is currently a highly challenging procedure into an easier and more reproducible procedure.

There are logistical issues, not to mention financial ones, involved with having allografts available for labral reconstruction, particularly if primary reconstruction is to be considered. This currently inevitably means that the procedure is not as widely available as it would ideally be.

The role of stem cells in labral reconstruction is yet to be established. Furthermore, the role of a composite chondrolabral (labral and articular cartilage) graft is yet to be explored.

The next decade is likely to witness a steep increase in the adoption of labral reconstruction, particularly as improved instrumentation is developed and released. Ongoing research will establish definitively the role of labral

Fig. 15.8 Fascia lata allograft: (**a**) being prepared for use; (**b**) allograft tubularised and ready for use

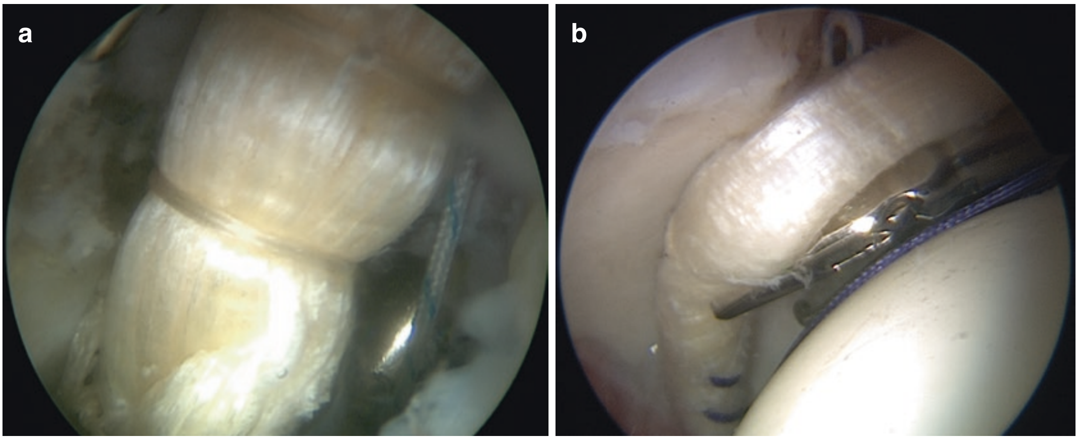


Fig. 15.9 (**a**) Allograft is passed into hip joint through the DALA portal. (**b**) Allograft being manipulated into position

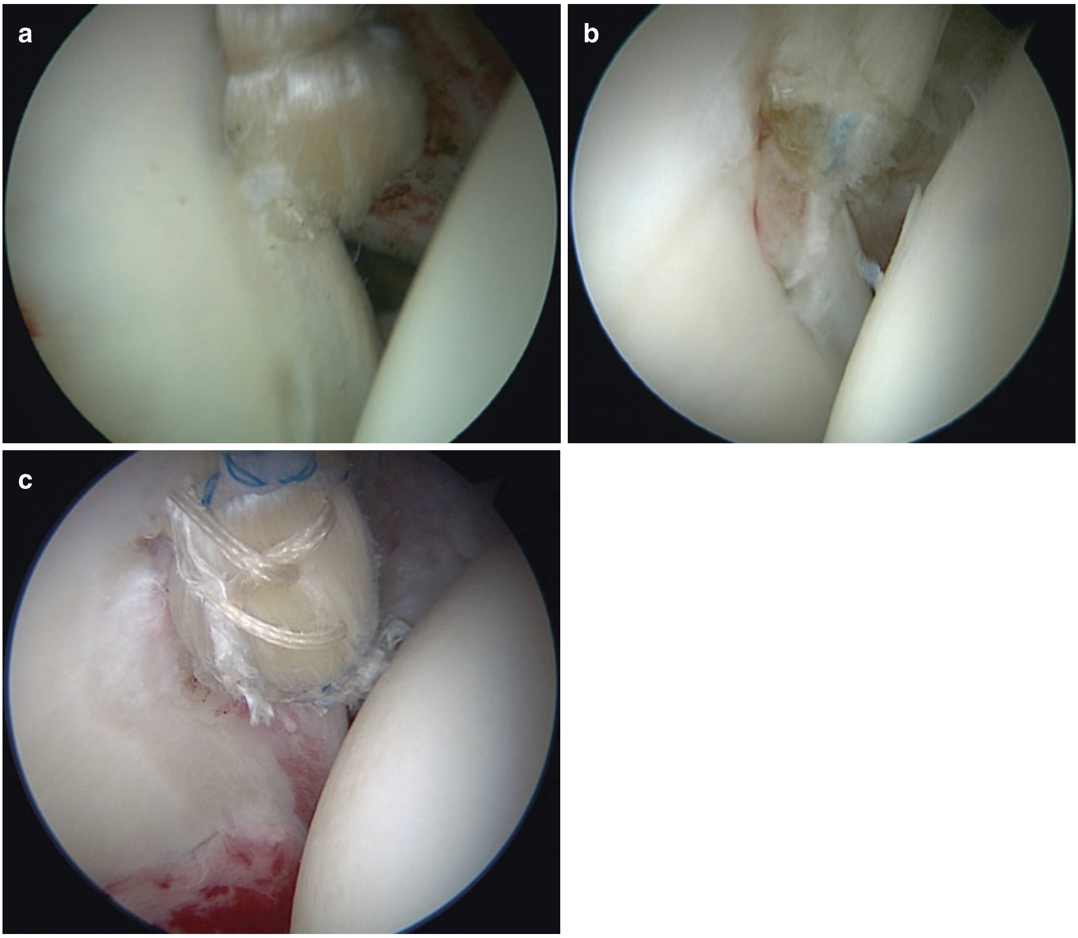


Fig. 15.10 Anterior end of allograft secured with Q-Fix suture anchor in three different cases: (**a**–**c**)

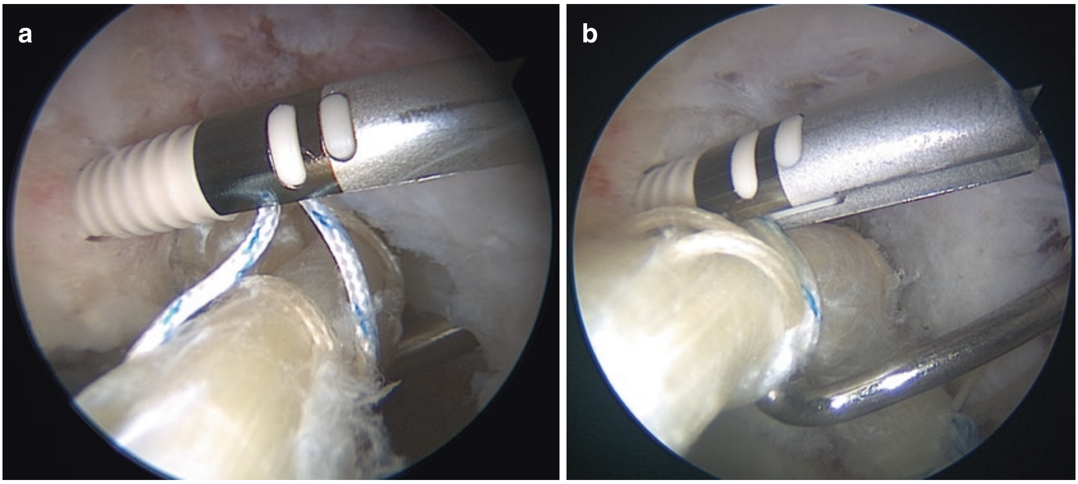


Fig. 15.11 Speedlock suture anchor securing allograft superiorly: (**a**) anchor is placed into the pre-drilled hole; (**b**) partial tensioning allows accurate placement of suture relative to anchor, and anchor is then tapped into position and final tensioning achieved

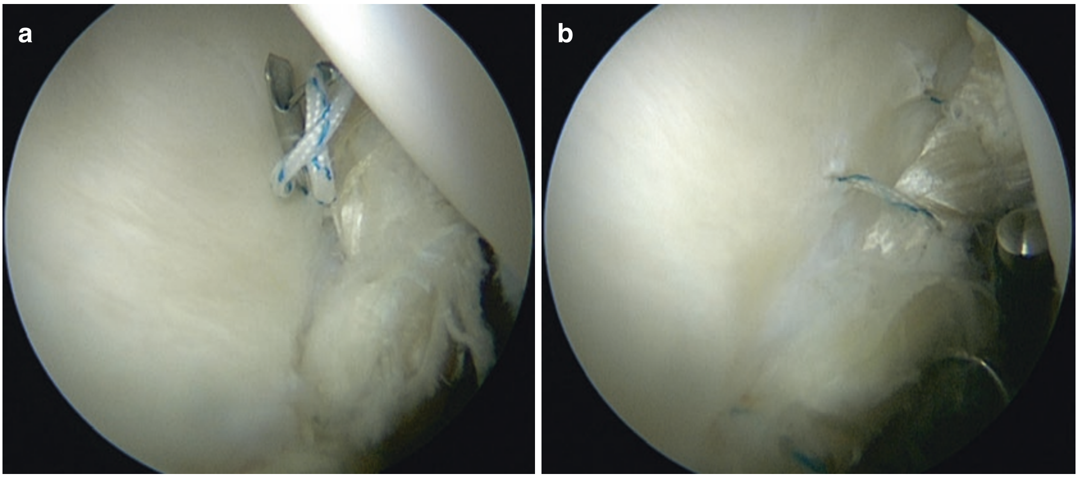


Fig. 15.12 Posterior end of graft secured with Q-Fix suture anchor: (**a**) suture passed through native labral stump; (**b**) Q-Fix all-suture anchors posteriorly secure the graft to the native stump with an overlap

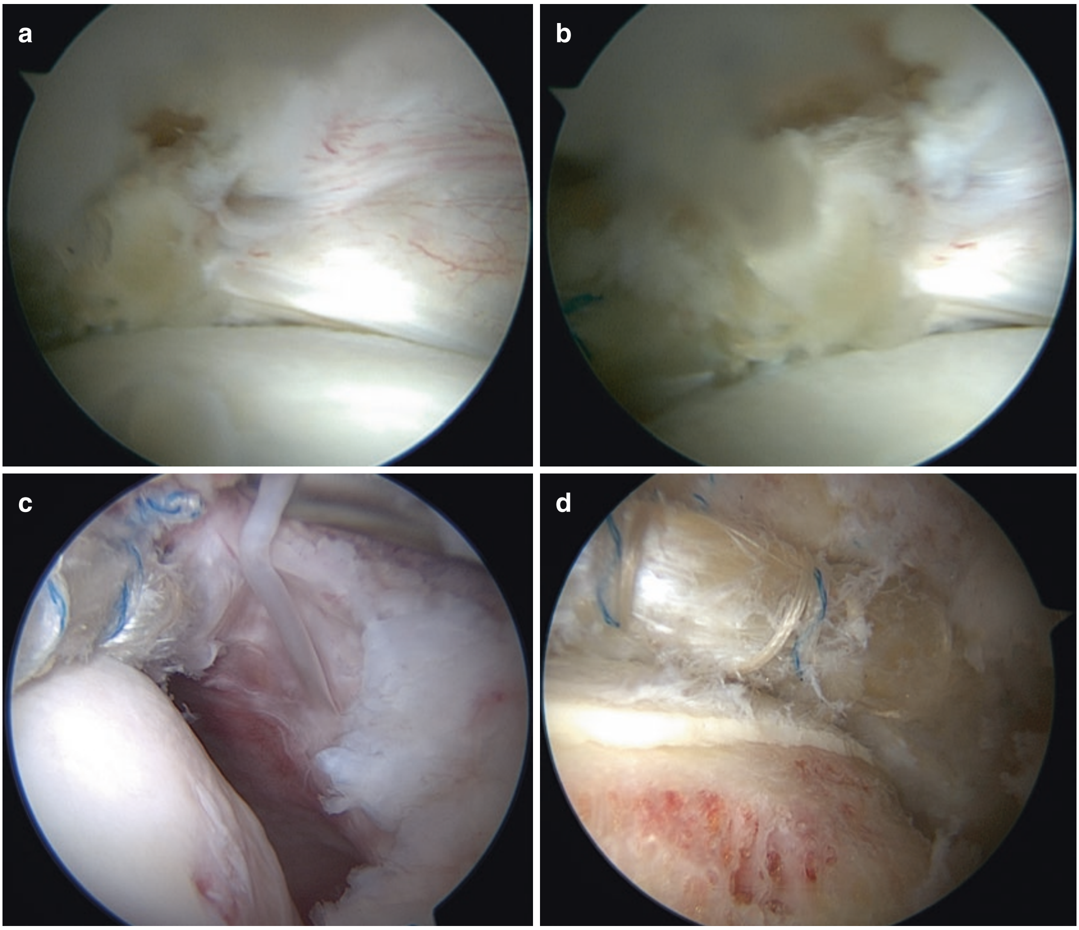


Fig. 15.13 Inspecting the labral seal with traction released: (**a**, **b**) viewing the anterior anastomosis of allograft and native labrum at level of psoas notch; (**c**) view of allograft over anterior hip confirming labral seal; (**d**) a different case where femoral osteoplasty was required, still confirming labral seal

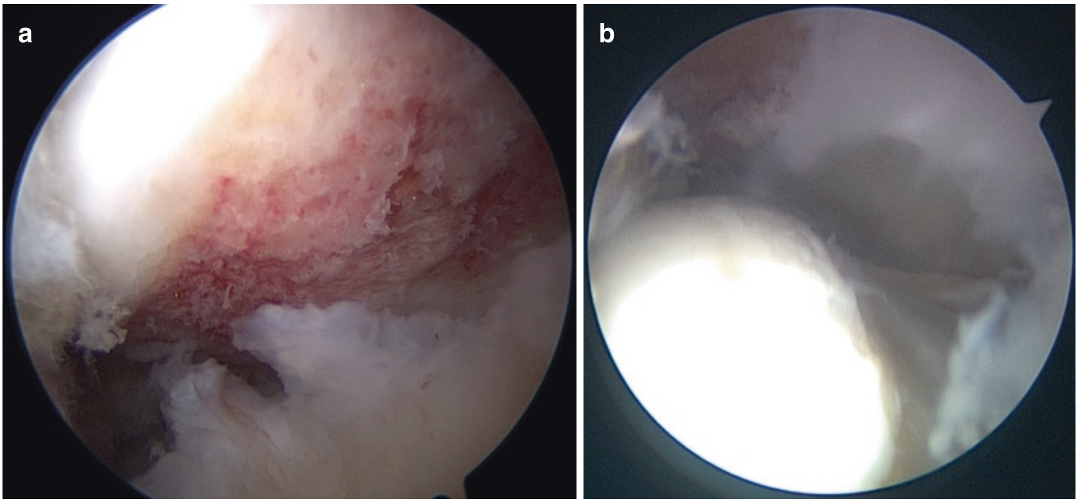


Fig. 15.14 Ensure appropriate femoral head–neck offset and femoral neck contour: (**a**) femoral neck in a right hip viewed from anterior portal looking posteriorly; (**b**) femoral head–neck junction in a different case confirming appropriate offset

reconstruction and will determine whether reconstruction can deliver superior outcomes to labral repair.

Tips and Tricks in Labral Reconstruction

Pre-operative Planning

1. Labral reconstruction is technically a highly demanding procedure, and so before considering carrying out your first case, ensure that you have been appropriately trained in the techniques of labral reconstruction. Preferably go on an approved cadaveric course and spend some time with an experienced surgeon who carries out these procedures regularly.
2. When considering reconstruction for cases where arthroscopic surgery has already been carried out previously, ensure that there is no other persisting structural cause for ongoing symptoms. If there is, this would need addressing prior to carrying out a labral reconstruction.
3. Plan to use allograft for your first case as the tissue handling properties are more favourable than autograft.
4. Be familiar with the different graft materials (for the reconstruction) and practice graft preparation before undertaking your first case. Ensure the allograft is tubularised and tightly packed to avoid it becoming engorged once in the joint.

At Operation

5. Consider using fluoroscopy, before starting the arthroscopy, to check the femoral head–neck offset and femoral neck contour. Plan to carry out a femoral osteoplasty as necessary to restore appropriate head–neck offset.
6. At arthroscopy always carry out a diagnostic round first to ensure that the ligamentum teres is intact and that the articular surface is well preserved. Both of these are pre-requisites for a successful outcome from labral reconstruction.
7. Do not be afraid to use four portals, as this will increase efficiency and reduce operative time.
8. Use appropriate portal savers (for example, the EZ switch from Conmed) to increase operative efficiency.

9. Plan to use an allograft that is longer than needed, so that it can be secured front to back and then cut off the excess. Prepare it as described in step 4.
10. Use the better end of the prepared graft as the anterior end, and do not use a stay suture in this end of the graft.
11. Use a long stay suture in the posterior end of the graft, so that once the graft is introduced into the joint through the DALA portal, this stay suture can be brought out of the joint through the most posteriorly placed portal and be used to keep the graft under appropriate tension when then securing the front end of the graft.
12. Carry out an appropriate labrectomy and acetabular rim trim, and then predrill all anchors. Ensure that the anchors are as close to acetabular rim as possible, as otherwise they will tend to evert the labral graft and compromise the labral seal. Use of the DALA portal for drilling (all but the most anterior and most posterior) anchors will facilitate this.
13. Use a pre-sited (all-suture) Q-Fix anchor suture to tie down the anterior end of the graft (close to or inferior to the psoas notch).

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16

Ligamentum Teres Injuries and Treatment

Dror Lindner, Ron Gilat, and Benjamin G. Domb

16.1 Introduction

Since the nineteenth century, the anatomy and mechanical properties of the ligamentum teres (LT) have been studied. However, traditionally the LT has been considered a vestigial structure with no role in the biomechanics or vascularity of the adult hip [1]. In recent years, the LT has become the subject of increased attention due to its role in hip stability and a potential pain generator [2, 3]. Moreover, recent studies have suggested an association between LT tears and articular cartilage damage [4]. Previous studies reported the prevalence of LT tears to be 5–50% in patients undergoing hip arthroscopy [5, 6]. However, a recent study by Chahla et al. found LT abnormalities in up to 89.5% of hip arthroscopies ($N = 2213$) performed for femoroacetabular impingement (FAI), with complete tears more likely to be seen in women, lower body mass index, and lower central edge angles [7, 8]. Advancements in imaging modalities and increasing use of hip arthroscopy have led to a better understanding of the LT functions and pathologies and paved the way to the development of several treatment approaches and surgical techniques.

16.2 Anatomy and Histology

The normal LT is pyramidal in shape, along its acetabular aspect, gently transitioning into a round or ovoid shape near its femoral attachment [9, 10]. The LT arises from the transverse acetabular ligament and the posterior inferior portion of the acetabular fossa and attaches to the femoral head at the fovea capitis [11]. The fovea capitis is located slightly posterior and inferior to the center of the femoral, and it is ovoid in shape and is not covered by hyaline cartilage. The LT has a broad origin that blends with the entire transverse ligament of the acetabulum and is attached to the ischial and pubic sides of the acetabular notch by two bands. The overall length of the ligament is 30–35 mm [10, 12]. A recent cadaveric study by Mikula et al. found the broad acetabular origin of the LT to have six consistent anchoring points: pubic, ischial, iliac, anterior, posterior, and transverse attachment [13, 14]. The LT has three bundles: anterior, posterior, and medial. The posterior band is the longest, and the medial one is the thinnest [10]. The LT is tightened to limit abduction, and internal and external rotation [15]. Its arterial supply is provided by the anterior branch of the posterior division of the obturator artery. Vascular canals extend a short distance from the fovea capitis into the femoral head [16].Yet its contribution to the femoral head's blood supply varies as these canals are occluded in one-third of the adult population.

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The LT is surrounded by a synovial membrane which is a thin layer, composed of a single layer of cuboidal epithelium, and lies over a sub-synovial layer of vessels and adipose tissue. The LT is composed of parallel bundles of well-organized collagen fibers [17]. The major collagen type found in the mature LT is type I, but type III and type V are also typically present. The LT is similar in its collagen distribution to the collateral ligaments of the knee but differs in that the attachments of the LT to the femur and the acetabulum lack the fibrocartilage which is usually found around ligaments' insertion sights [18]. The dispersion of collagenous fibers at the cartilage surface and the lack of reach to the thin subchondral bone of some fibers may weaken the LT at its insertion to the femoral head [19].

Histological studies have found LT possesses both mechanoreceptors and nociceptors [10, 20], specifically type IVa receptors (unmyelinated nerve fibers), suggesting the LT plays a part in the integral reflex system which is involved in joint protection, sense of pain, and proprioception.

How the LT contributes to normal hip biomechanics and stability is still debatable. Some surgeons view the LT as having a negligible role in hip biomechanics and stability; for example, open surgical dislocations require transection of the ligament and are therefore based on the premise that sacrifice of the LT is inconsequential. In contrast, others believe that its role in the normal hip biomechanics and stability warrants its reconstruction. A recent cadaveric study by Jo et al. found that LT can minimally limit external rotation when the hip is in the flexed position but does not contribute to translation stability [21]. Another cadaveric study by Philippon et al. elucidated more on the LT biomechanic properties and found the mean load to failure of the LT was 204 N [22].

Several theories regarding the LT's function in the hip have been proposed. Having both nociceptors and mechanoreceptors, it has been postulated that the LT acts as a stabilizer to prevent excessive joint movement. The similarities between the LT and the anterior cruciate ligament (ACL) led to the theory that the LT serves a similar role in the hip as the ACL in the knee; acting as a strong intrinsic stabilizer that resists joint subluxation forces. Besides the similarities to the ACL in regard to mechanical strength, being an intra-articular structure, having free nerve endings, similar bundled appearance, and similar collagen distribution, it has also been shown in animal models that hips without LT have higher rates of dislocations [23]. Moreover, the understanding that the LT is tightened in flexion external rotation and extension internal rotation, in which the hip is the least stable, further supports the theory regarding its role as an intrinsic hip stabilizer. In addition to its contribution to normal hip biomechanics and stability, it has been theorized that the LT plays a role in the distribution of synovial fluid within the joint ('the windshield wiper') [24].

16.3 Classification of Injuries

The most common classification system used is that of Gray and Villar [24], they described three types of injuries to the LT: Type I—Complete, Type II—partial tears, and Type III—degenerative tears. They based their classification system on 472 hip arthroscopies where they identified a cohort of 20 patients with LT pathology.

A descriptive classification system was also proposed [5]: Type 0—intact ligament, Type 1—tear of less than 50% of the ligament fibers, Type 2—tear of more than 50% of the ligament fibers, but not a complete tear, Type 3—complete tear of the LT. The study included 284 patients with LT injuries, out of 558 patients undergoing primary hip arthroscopy.

Of note, both classifications have only fair interobserver reliability, with a higher absolute agreement rate for the descriptive classification. Normal, partial, and low-grade tears are prone to disagreement and major discrepancy in interpretation [25].

Combing the two classification systems would create a concise classification system that would be treatment oriented and consistent among surgeons.

A more recent classification by O'Donnel and Arora had incorporated the presence of synovitis and hypermobility. Hypermobility is defined by a

Beighton score ≥ 4. LT pathology is divided according to severity: 0 = normal, 1 = synovitis, 2 = partial tear, and 3 = complete tear. They have also proposed a treatment algorithm based on their classification and available literature [26].

16.4 Clinical History

The patient chief complaint should be obtained, specifically asking about pain, clicking, locking, catching, and giving way or any sense of instability. Making the differentiation between pain and instability is critical.

Duration of symptoms should be established and specifically the onset of symptoms; to delineate whether symptoms started after a traumatic event or had insidious onset is crucial. In cases of a traumatic event, the exact mechanism of injury should be revealed. Previously LT tears were mainly diagnosed in the rare event of acute hip dislocations, which usually results from high-energy trauma [27], whereas today, the majority of patients with LT tears report low energy injury or no injury at all [5, 6]. Proposed injury mechanisms which might cause LT tears are flexion adduction with axial loading, acute twisting injuries, hyperabduction, and excessive external or internal rotation [10, 28]. Participating in high-impact sports, such as American Football, hockey, rugby, Australian Football, or activities that require extreme range of motion, such as gymnastics, martial arts, and particularly ballet [29], predisposes the participant to these proposed injury mechanisms and the potential risk of sustaining an LT tear.

Additional intra-articular pathologies are often found with LT tears; therefore, a detailed account of past treatments for the symptoms is required including nonoperative treatment, injection, and surgery.

Medical and family histories should be investigated for connective tissue disorders such as Ehlers-Danlos syndrome, Arthrochalasis multiplex congenita, Marfan syndrome, and Down syndrome.

16.5 Physical Examination

There is no physical examination specific to the detection of LT tears, and the majority of the patients will have additional intra-articular pathology [6, 30], emphasizing the need for detailed clinical history, evaluation of the mechanism of injury, and a high level of suspicion. A complete examination of the hip should be obtained, including gait evaluation, active and passive range of motion (flexion, extension, internal, and external rotation), tenderness to palpation around the groin, greater trochanter, piriformis, and adductors. Required provocative tests include the anterior impingement test, lateral impingement test, posterior impingement test, and FABER test. Pain and apprehension are recorded in all tests. Assessment of muscle strength and general joint laxity is also mandatory.

Specific tests to evaluate hip stability include the Domb's test: the patient is positioned prone, the examined limb is flexed at the knee to 90°, and the hip is externally rotated and anterior pressure is applied to the hip. A positive response would be a sense of apprehension or anterior hip pain. Supine log roll test, evaluating for difference in the range of motion as well as apprehension during external rotation would indicate hip instability. The dial test: the patient lies supine; the examined limb is internally rotated. The limb is then released and allowed to externally rotate. The test is positive when the patient's limb passively rotates >45° from vertical in the axial plane and lacks a mechanical end-point. The contralateral limb is tested for comparison.

16.6 Imaging

Evaluation of all hip suspected of intra-articular hip pathology should begin with radiographic imaging: an anteroposterior (AP) pelvic view, Dunn view, cross-table lateral view, and a false-profile view [31–33], to assess for any bony abnormalities. We recommend obtaining bilateral imaging at least in AP view, to allow comparison and the differentiation between bony pathology and normal variants. Measurements performed on these views include the Tonnis angle (acetabular inclination angle (AI)) using the method described by Jessel et al. [34] and the lateral center edge (CE) angle of Wiberg [35]. These two measurements allow the calculation of the lateral coverage index (LCI): LCI = CE − AI. The LCI has been shown to correlate with the presence of LT tears [6]. The presence of arthritis should be evaluated and can be graded using the Tonnis classification of osteoarthritis [36].

In cases of traumatic hip injury or dislocation, computed tomography (CT) is useful in detecting small nondisplaced acetabular fracture as well as small LT avulsion fractures and intra-articular loose bodies.

When an intra-articular source of pain is suspected, magnetic resonance imaging (MRI) allows for a detailed evaluation of soft tissue structures. MR arthrogram provides superior accuracy over plain MRI [37] in detecting LT tears. However, it may still be challenging to differentiate between an intact ligament to a partially torn one [38]. Partial LT tears are characterized by abnormal intrasubstance signal intensity, focal partial loss of continuity, thickening of the ligament due to scar tissue formation, and abnormal ligament attenuation [9, 38]. Acute complete tears are not as challenging to detect as the partial tears and may be detected using plain MRI or MR arthrogram. Signs of a complete tear include discontinuity of the ligament fibers, wavy contour, and increased signal intensity on T2.

16.7 Treatment

In general, a traumatic LT tears are initially managed nonsurgically with rest and activity modification followed by physical therapy. In cases where the above-mentioned nonsurgical modalities are unsuccessful, intra-articular injection may be considered. Surgical intervention is considered after nonsurgical treatments have failed or in cases of an avulsion fracture of the LT with an intra-articular osteochondral fragment.

The effect a torn LT has on the hip is still debatable, whether it creates micro-instability that causes additional joint damage or whether there is micro-instability or predisposing factors leading to LT tears [6, 39].

Currently, the surgical treatment options for LT tears are performed arthroscopically, including arthroscopic debridement, shrinkage, augmentation, and reconstruction. Since in the majority of patients, LT tears are accompanied by additional intra-articular pathologies, arthroscopy offers the opportunity to address them concomitantly.

Arthroscopy is carried out under general anesthesia, the patient is placed in the supine position on a traction table or fracture table, both feet are well secured and padded, and a perineal post is used to protect the genitalia. The hip is prepped and draped in the usual fashion. Traction is applied and a spinal needle, under fluoroscopic visualization, is inserted into the joint and the joint is vented. After venting of the joint, additional traction is applied. The needle is retracted, and Marcaine is injected into the subcutaneous tissues. Correct portal placement is located using fluoroscopic visualization. The anterolateral portal is first established using an 11 blade for the skin. A spinal needle is inserted through the incision and into the joint, taking care to avoid the labrum and the femoral head. An over-the-guidewire technique is used to insert a 70-degree scope through a 4.5 mm cannula. A mid-anterior portal is established using the same over-the-guidewire technique. A beaver blade is used to perform capsulotomy, incising the capsule parallel to the acetabular rim in order to connect the two portals.

Arthroscopic debridement and shrinkage are carried out in a similar fashion: evaluation is performed by visualizing the LT through the anterolateral portal and probing using the mid-anterior portal. In cases of complete tears, the stump is debrided using a curved shaver. In partial tears the curved shaver is used to debride any frayed or torn portion followed by shrinkage of the partially torn ligament, which is carried out using a long, thin, flexible radiofrequency ablation probe. Debridement of the ligament is best performed when the hip is externally rotated, this will increase the tension on the ligament as well as deliver it anteriorly. Shrinkage should be performed when the hip is in a neutral position and should be performed sparingly in order to avoid limiting internal rotation.

Arthroscopic augmentation of the LT with suture tape had also been described in a technical note [40], but we are unaware of any data regarding the outcomes of the procedure.

LT reconstruction has been reported in case reports [41], surgical techniques [42–45], and small case series [46, 47]. Techniques for LT reconstruction are evolving and further studies reporting outcomes data are required.

In this chapter, we describe our preferred technique which had been published by the senior author [48]. In the development of this technique, numerous procedures were performed in cadaver hips and were followed by open dissections to assess the proximity of the bone tunnels to the obturator vessels and identify additional challenges. The result was a technique that was found to be both feasible and reproducible. We describe our technique for reconstruction of the ligamentum teres herein.

16.8 Surgical Technique

16.8.1 Patient Positioning and Portals

Under general anesthesia, the patient is placed in the supine position on a traction table or fracture table, both feet are well secured and padded, and a perineal post is used to protect the genitalia. The hip is prepped and draped in the usual fashion. Traction is applied and a spinal needle, under fluoroscopic visualization, is inserted into the joint and the joint is vented. After venting of the joint, additional traction is applied. The needle is retracted, and Marcaine is injected into the subcutaneous tissues. Correct portal placement is located using fluoroscopic visualization. The anterolateral portal is first established using an 11 blade for the skin. A spinal needle is inserted through the incision and into the joint, taking care to avoid the labrum and the femoral head. An over-the-guidewire technique is used to insert a 70-degree scope through a 4.5-mm cannula. A mid-anterior portal is established using the same over-the-guidewire technique. A beaver blade is used to perform capsulotomy, incising the capsule parallel to the acetabular rim in order to connect the two portals.

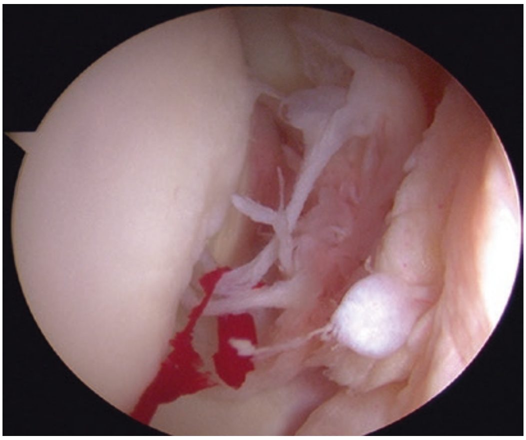
Fig. 16.1 Arthroscopic view of the left hip demonstrating complete tear of the ligamentum teres

A diagnostic arthroscopy is performed, switching portals frequently to access all parts of the joint. Any additional pathology in the joint is addressed prior to LT reconstruction. Care should be taken to identify central acetabular osteophytes or a prominent posterior acetabular fossa edge. Both pathologies have been associated with an LT tear and resection of these bony prominences should be performed prior to LT reconstruction [49, 50]. The LT is examined and probed upon identification of a complete tear (Fig. 16.1); the stump in the acetabular fossa is cleared using the Nav X ablation device (Arthrex, Naples, FL) and a shaver (Fig. 16.2).

16.8.2 Graft Preparation

The graft choice may include a semitendinosus autograft or allograft. The double-stranded graft is prepared with maximal length on a Retro-Button (Arthrex, Inc., Naples, FL), with the graft sutured to the button using a 2 mm loop. The graft should be prepared prior to tunnel preparation.

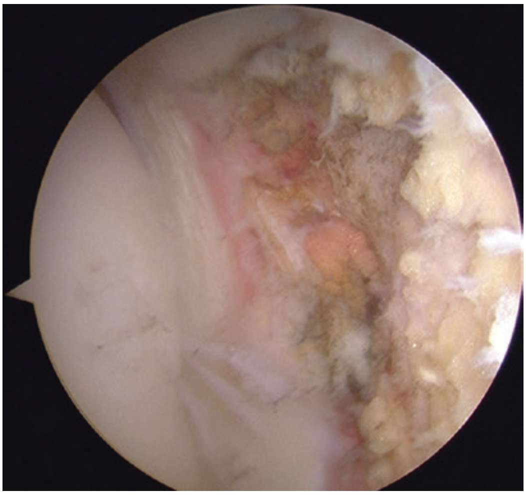

Fig. 16.2 Arthroscopic view of the left hip after debridement of the LT stump from fossa

Fig. 16.3 Fluoroscopic intraoperative image. After reaming the femoral tunnel over a guidewire, the guidewire is passed through the femoral tunnel into the desired location of the acetabular tunnel. The guidewire is drilled into the acetabular footprint, with care not to penetrate the medial cortex of the acetabulum

16.8.3 Femoral and Acetabular Tunnels

A lateral 2 cm incision is made to approach the femoral transtrochanteric tunnel; the location is determined using fluoroscopy. A 3.2 mm guidewire is passed through the lateral cortex of the greater trochanter, exiting through the center of the fovea in the footprint of the LT. This is done in a "freehand" technique using fluoroscopic assistance and direct visualization of the guide's exit point in the fovea. Over the guidewire, a cannulated reamer is used to create the femoral tunnel. The reamer size used is determined by the graft size, which is measured during graft preparation. A shaver and wand are inserted through the femoral tunnel to complete the preparation of the footprint at the base of the acetabular fossa.

Drilling of the acetabular tunnel is performed through the femoral tunnel in order to achieve correct tunnel positioning in the cotyloid fossa. Optimization of the acetabular tunnel can be achieved by 15° of internal rotation and 15° of abduction [51, 52]. The anatomic insertion of the LT in the cotyloid fossa is made in the inferior portion of the fossa. In order to maintain a safe distance from the obturator vessels, the tunnel is placed slightly posterior to the center of the base of the fossa. The concept of safe acetabular drilling and safe zones is well-established and has been in use by surgeons performing hip arthroplasty for screw placement in the acetabular component. It was first described by Wasielewski et al. [16, 17, 53], in which they described the posteroinferior and posterosuperior quadrants to be safe for drilling, whereas the anterior quadrants were not. The structures at risk while drilling in the posteroinferior portion of the cotyloid fossa are the obturator artery and vein, but they are at a safe distance from the exit point of the drill [15].

A guidewire is placed through the femoral tunnel and into the posteroinferior portion of the fossa; its position is verified by direct visualization. Upon achieving the correct position, the guide is drilled to the medial cortex, without penetrating it, using fluoroscopic assistance (Fig. 16.3). Over the guidewire, a cannulated reamer is used to create the acetabular tunnel. The reamer used is determined by the graft size which is measured during graft preparation. Fluoroscopic assistance is used to assure the guidewire is not penetrating into the pelvis, and the drilling is performed cautiously to avoid plunging through the medial cortex of the acetabular fossa.

16.8.4 Graft Placement

Once both tunnels are prepared, the graft is passed through the tunnels. Graft placement is performed using direct visualization and fluoroscopic assistance. Two knot pushers are used to lead the graft/button complex through the tunnels; one knot pusher is used to lead the button through the tunnel, and the second knot pusher is used to flip the button over the medial cortex. Once the button has been flipped, tension is placed on the graft and fluoroscopy is used to assure that the button has flipped and is secure.

The motion and tension of the graft are examined in internal and external rotation while the hip is in traction. The traction of the leg is then released while maintaining traction on the graft. The leg is positioned in 10° of hyperextension and 60° of external rotation, and a PEEK interference screw (Arthrex, Inc., Naples, FL) is used for femoral fixation. Once the graft is secured, traction is reapplied, the arthroscope is reintroduced, and the graft is again examined (Fig. 16.4) throughout the range of motion. The excess graft is cut flush with the lateral cortex of the femur.

The portals are closed using 3–0 monocryl, and the distal incision is closed using #1 Vicryl for the fascia, 2–0 Vicryl for the subcutaneous layer, and 3–0 monocryl for the skin. The patient is placed in a X-Act ROM hip brace (DJO Global, Vista, CA) and an abduction pillow.

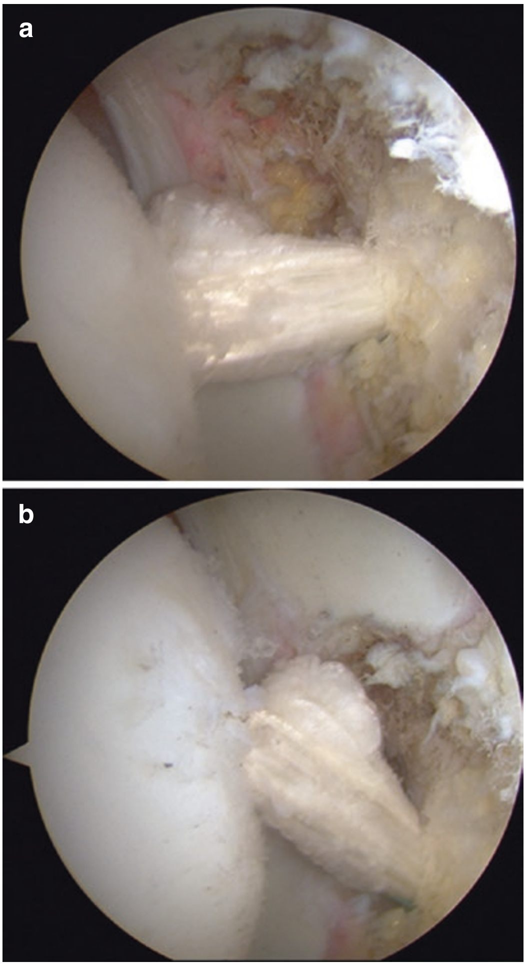

Fig. 16.4 Arthroscopic view, after graft fixation, evaluating the graft through the range of motion; (**a**) hip in neutral position, (**b**) hip in external rotation

16.9 Rehabilitation and Recovery

For the first 6 weeks, the patient is kept in a hip brace locked at 0–90° of flexion at all times and is restricted to 20 lb foot-flat weight-bearing. In addition, an abduction pillow is used at night for the same period. The patient starts physical therapy on the first postoperative day and is instructed to refrain from adduction and external rotation. Six weeks postoperatively, the brace and crutches are discontinued, and the patient continues physical therapy with an emphasis on strengthening the gluteus medius and core muscles as well as on gradual progression in range of motion and activities.

16.10 Discussion

The LT has been studied since the nineteenth century, but only in recent years have we started understanding its true function. Today we know that the LT is as strong as the ACL, is tight in flexion, external rotation, and abduction, and plays a role in hip proprioception and pain (nociceptors and mechanoreceptors) [9]. Also, studies have reported preliminary data suggesting the presence of an LT tear is associated with chondral damage [39, 54].

The evidence is growing in regard to the clinical implications of an LT tear. Chaharbakhshi et al. performed a matched-controlled study

($N = 68$), evaluating the effect of an LT tear on outcomes of patients with borderline dysplasia undergoing hip arthroscopy. Following a minimum 2-year follow-up, they found the concurrent presence of an LT tear may indicate advanced instability and portend slightly inferior outcomes. They also suggested that in these patients, the presence of an LT tear may have increased propensity toward revision arthroscopy and conversion to arthroplasty [55]. Maldonado et al. also performed a match-controlled study ($N = 54$) of patients with complete LT tears vs. patients with an intact LT undergoing primary hip arthroscopy for FAI. They found significant improvement in patient-reported outcomes (PROs) in both groups. However, with a complete LT tear were three times more likely to require an eventual total hip arthroplasty [56].

The current standard surgical treatment for LT tears consists of debridement, with several studies reporting good outcomes [57]. Byrd et al. reported on 23 patients who underwent debridement of LT tears with good outcomes. However, 15 patients in their study group had additional pathologies that were addressed during surgery [11]. Haviv and O'Donnell in a series of 29 patients reported on isolated LT tears, reporting improvement of 16 points in the modified Harris Hip Score (mHHS); however, five patients (17%) required revision surgery. Despite the good results reported with debridement, a subset of patients was experiencing residual pain and instability following LT debridement [58]. Pergaminelis et al. performed a retrospective study reporting improved clinical outcomes with a minimum of 6-month follow-up after radiofrequency debridement of solitary LT tears [59]. Amenabar et al. also reported improvement in PROs following debridement of isolated partial-thickness LT tears in their prospective case series [60].

Economopoulos et al. found posterior bony impingement of a prominent posterior acetabular fossa edge to be an uncommon cause for LT tears. They reported good outcomes with LT debridement in combination with resection of the impinging bone [50].

There is limited literature regarding clinical outcomes following LT reconstruction. Philippon et al. described a case series of four patients who underwent LT reconstruction with an iliotibial band autograft with early promising clinical results [46]. Chandrasekaran et al. reported a case series of four patients with connective tissue disorders and generalized ligamentous laxity undergoing arthroscopic reconstruction of the LT. They found improvement in patient-reported outcomes in three of the four patients with a 2-year follow-up [47].

Currently, the indications for LT reconstruction have yet to be established; however, it may be considered for patients with isolated complete LT tears [61] who report subjective hip instability and have increased external rotation.

We have found this technique of LT reconstruction to be safe and reproducible. Further studies on LT reconstruction are required to establish the exact role and recommendations for the use of LT reconstruction in the treatment of tears of the ligamentum teres.

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17

Capsular Plication and Repair

Bent Lund

17.1 Introduction

The hip is seen as an inherently stable joint, and the acetabular coverage, version and depth, femoral version, torsion, and joint congruency form the foundation for a stable hip function. The labrum and the hip capsule act as secondary stabilizers and create a powerful suction seal that is imperative for an optimal function of the joint. The muscles act as the tertiary dynamic stabilizers of the hip joint.

Over the past decade, hip arthroscopy has evolved from a rare operation in a highly specialized setting to a routine operation performed in an everyday setting in many hospitals and clinics. Thus, we have also begun to see problems and complications in conjunction with the procedure. Some of these complications relate to the capsule and the management here of during surgery.

Distracting the hip and performing capsulotomies during the procedure was previously believed to be fairly benign, and the capsule was by many believed to heal without problems postoperatively, even without capsular closure at the end of surgery. But time and experience has shown that in some patients, these capsulotomies do not always heal and that some patients seem to have problems with microinstability and even gross instability and in a few rare cases even outright hip dislocations [1]. That has led arthroscopic hip surgeons to perform capsular closures and plication of capsular tissue in some patients and even reinforcement of capsular structures with allo- or autograft tissue in patients with capsular defects either due to trauma or iatrogenic damage [2].

17.2 Background

The hip capsule consists of a ligamento-fibrous structure with three external ligaments directed longitudinally as well as internal fibers going more circumferentially. The external ligaments consist of the iliofemoral ligament (IFL), ischiofemoral ligament (ISFL), and pubofemoral ligament (PFL) (Fig. 17.1). The internal circular fibers of the capsule define the zona orbicularis (ZO), and the inside is lined with synovium. The midportion of the capsule is thickest superiorly; this region represents the IFL, and it is the site of the interportal capsulotomy during hip arthroscopy. The capsulotomy runs between the anterolateral and mid-anterior arthroscopic portals [3]. Thus, an interportal capsulotomy may traverse

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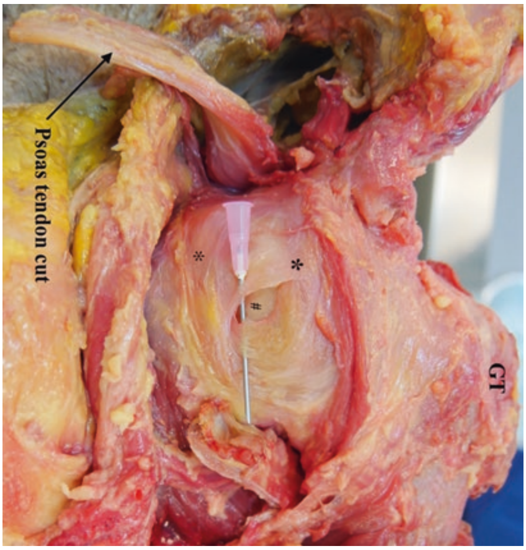

Fig. 17.1 Left hip cadaver specimen. The psoas tendon is transected, and there is a hole in the capsule from the psoas tendon (*GT* greater trochanter, ∗ *IFL* iliofemoral ligament, # hole in capsule, and ✻ *PFL* pubofemoral ligament). (With kind permission from Prof. Annemarie Brüel, Institute for Biomedicine, Aarhus University)

the whole width of the IFL, and it may cause capsular laxity and instability if not properly repaired.

17.3 Capsulotomy

A biomechanical study investigating the effect of different capsulotomies on hip stability found that the larger the capsulotomy, the greater the degree of hip rotation, and hip capsulectomy and an unrepaired T-type capsulotomy resulted in the greatest degree of rotation [4]. Especially in treating borderline dysplastic patients or patients with generalized ligamentous laxity, the hip arthroscopist should be aware of potential microinstability. Developmental dysplasia of the hip (DDH) is defined by a lateral center edge angle (LCEA) of <20° and Tönnis angle (AI) >12° with borderline dysplastic patients having LCEA angles between 20° and 25°. DDH and borderline dysplasia result in undercoverage of the femoral head by the acetabulum, and this alters the hip joint biomechanics and places additional stress on the labrum, anterior capsule, and dynamic stabilizers [5–7]. In a dysplastic or borderline dysplastic patient, the hip function has to rely more on the soft tissue stabilizers around the hip (cartilage, labrum, capsule, and muscles) for stability through the full range of motion, and a large capsulotomy may worsen their instability. Capsular laxity and microinstability may arise secondarily to connective tissue disorders, such as Ehlers–Danlos and Marfan syndromes, but can also be seen in patients with repetitive microtrauma of the hip (ballet dancers and martial art athletes) [8, 9].

17.4 Surgery

In order to gain access to the central compartment and be able to address the various pathologies found at surgery, several different techniques have been described. My preferred technique is with the patient placed in supine position on a specialist traction table and I use a so-called "central first technique" and will start by putting traction on the hip in order to gain access to the central compartment at the start of the procedure. Another way to start the surgery is by going directly to the peripheral compartment and then gaining access to the central compartment. When access has been gained, most surgeons will perform some sort of capsulotomy in order to create more space to work in. These include "ballooning" of the capsule, capsulectomy, extensile interportal capsulotomy, or T-capsulotomy [10–13]. Once the anterolateral (AL) portal and the mid-anterior portal (MAP) have been established, a transverse interportal capsulotomy is performed 5–10 mm from the labrum using a banana blade, and the cut measures approximately 2–4 cm in length. The size is dependent on the location of the pathology and the stiffness of the capsule, and varies from case to case. Bleeding from the soft tissues can be controlled, and synovectomy is performed with a radiofrequency ablator. When the central chondrolabral pathology has been treated and the labrum is repaired, the instruments are removed from the central compartment, and then traction is released. The hip is flexed to approximately 30–45°, and then some surgeons perform a T-capsulotomy by extending the interportal cap-

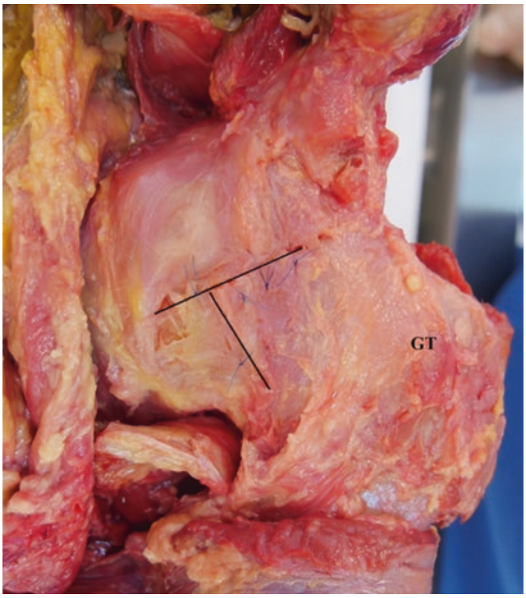

Fig. 17.2 Left hip cadaver specimen. Demonstrating a T-cut capsulotomy closed with single knots (*GT* greater trochanter). (With kind permission from Prof. Annemarie Brüel, Institute for Biomedicine, Aarhus University)

sulotomy distally at its midpoint through a distal anterolateral accessory (DALA) portal. I find that most cases can be treated from an interportal cut alone, and rarely a T-cut is needed (Fig. 17.2).

In order to facilitate that I use a suspension suture at the lateral capsule to lift up the capsular tissue and thereby enabling a better access to the lateral head–neck junction. The suture is used to pull on the capsule and lifting out the capsule from the lateral head–neck junction (Video 17.1). The cam resection is then performed with the hip going from flexion to full extension, and the resection is verified visually and using an image intensifier.

17.5 Capsular Repair and Plication

With growing experience, it is clear to me that capsular repair and capsular protection have a place in hip arthroscopy and especially in patients with capsular weakness/defects, atraumatic instability, or hyperlaxity. In a cross-sectional survey, Gupta et al. explained that only 11% of high-volume hip arthroscopists never closed the capsule compared to 48% that closed the capsule >50% of the time [14]. Capsular repair techniques are based on size, type, and location of the capsulotomy, as well as surgeon's preferences. In the case of a T-capsulotomy, the vertical arm is closed from distally to proximally, starting at the base of the IFL using a suture shuttling technique with a suture passer. Once the vertical limb of the T-capsulotomy is closed, the interportal capsulotomy can be closed with two to three sutures using a suture passer in the same manner. The posterolateral extent of the interportal capsulotomy is closed through the AL portal viewing from the MAP portal. The anteromedial extent of the interportal capsulotomy is closed through the DALA or AL portal using similar steps. The author's preference is to pass the sutures for the lateral aspect of the capsulotomy right after repairing the chondrolabral damage and before releasing the traction. The camera is placed in the MAP portal, and the sutures are passed through the AL portal using a half-pipe to facilitate the suture passer (Accu-pass Direct Crescent XL™). The double-looped #2 Vicryl suture is then left hanging, secured with a hemostat, and left for suturing at the end of the procedure. The portals are changed, the camera is switched back to the AL portal, the traction is released, and the osteochondroplasty resection is done. The hip is then flexed to approximately 45°, and one- or two-looped #2 Vicryl suture are then passed through the MAP portal using a suture passer through the anterior capsule. All the sutures are passed sequentially before tying in order to facilitate proper visualization. Then the sutures are tied from medial to lateral until the capsule is closed entirely. At the end of the procedure, the instruments and camera are removed, and the suture at the lateral aspect is tied with a sliding knot (Quebec City Slider) [15]. My preferred suture is a #2 Vicryl, but some authors prefer a #2 nonresorbable suture (Video 17.2).

In patients with hyperlaxity of the hip and capsule, a capsular plication or capsulorrhaphy must be considered. This is to limit capsular redundancy and to minimize microinstability due to the capsular laxity [6]. Capsular plication is performed with the hip in 45° flexion, so that side-to-side stitches may take larger bites of the capsule in order to reduce extraneous capsular elements and to decrease the capsular volume [10]. In patients with medial capsular defects after prior surgery, there is sometimes insufficient capsule proximally on the acetabular rim, and then a possible solution is to put one or two suture anchors at the rim and then use these to pull capsular material from distally toward the rim in a kind of plication technique. A few authors have described the use of allografts for capsular reconstruction [2, 16], but that is not something I have any experience with.

Tips and Tricks

Capsular Repair:

1. Make capsulotomy about 5 mm from the labral edge and parallel to the labrum.
2. At the end of the central work on labrum and cartilage, place camera in mid-anterior portal and look down on the anterolateral portal. Still with traction on and leg in full extension.
3. Place a looped #2 Vicryl through both sides of the capsule, using a suture passer. Do not tie it down, but secure with a clamp. Change portals again. Place the camera back to anterolateral portal.
4. Release traction and finish all the work in the peripheral compartment. Flex the hip to approx. 45° and then place a looped #2 Vicryl through both sides of the capsule in the front of the hip, and if there is room, add another next to it. Tie both down with a sliding knot f.ex. the Quebec City slider.
5. Extend the hip, pull out the camera, and tie down the first looped suture that was placed at the anterolateral capsule using a sliding knot. Cut all the sutures.

Capsular Plication:

1. Finish all the central and peripheral work. Place a looped #2 Vicryl at the anterolateral portal as described in the repair section. Perform a T-cut in the anterior capsule with a beaver blade or RF probe.
2. Flex the hip to about 45° and place a row of looped #2 Vicryl sutures along the T-cut and try to overlap the two edges of capsule as much as needed in order to tighten the capsule when tying the sutures.
3. Cut the sutures and extend the leg. Remove the camera and tie the lateral capsular suture.

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Part IV

Cartilage and Underlying Bone

Chondral Debridement–Abrasion: Microfracture

18

Marc Tey Pons, Xavier Lizano Diez,
Mahmoud Tahoun, and Joan Cabello Gallardo

18.1 Introduction

Hip preserving surgery has emerged as an important field in hip surgery in the recent years. It is promoted as a group of surgical strategies developed to improve the quality of life of patients with hip complaints and with a secondary intention of avoiding or at least delaying degenerative joint disease (DJD). The Stolzalpe's school promote that hip osteoarthritis in people younger than 55 years old is secondary to a known aetiology in 95% of the cases and to primary degenerative cases just in 5% [1], as shown in Graphic 18.1. Those known causes are mainly abnormal biomechanics (75%) or biologics (20%). In the first group, we have any anatomic variation that can lead to kinetic or kinematic disorder. Joint incongruency secondary to a fracture, acetabular overcoverage or aspherical femoral head is the usual problem that produces mechanical disorders with osteoarthritis (OA) as an end stage. Biological aetiologies are a wide spectrum from vascular disorders (avascular necrosis) to systemic diseases (rheumatic diseases).

Abnormal biomechanics is the main focus of adult's joint preserving surgery, and hip abnormal biomechanics can be divided into:

1. Post-traumatic joint incongruency.
2. Dynamic conflict of space.
3. Dynamic conflict of stability.

While very little can be achieved to avoid DJD after an articular fracture healed with a joint incongruency, long-term evidence has demonstrated that surgical treatment of dynamic conflicts of space and stability is beneficial for the patients in terms of quality of live and delaying DJD [2–4].

Hip preserving strategies should consider:

1. Improvement of Biomechanics. Classical surgical techniques were developed to restore or improve joint biomechanics, mainly joint

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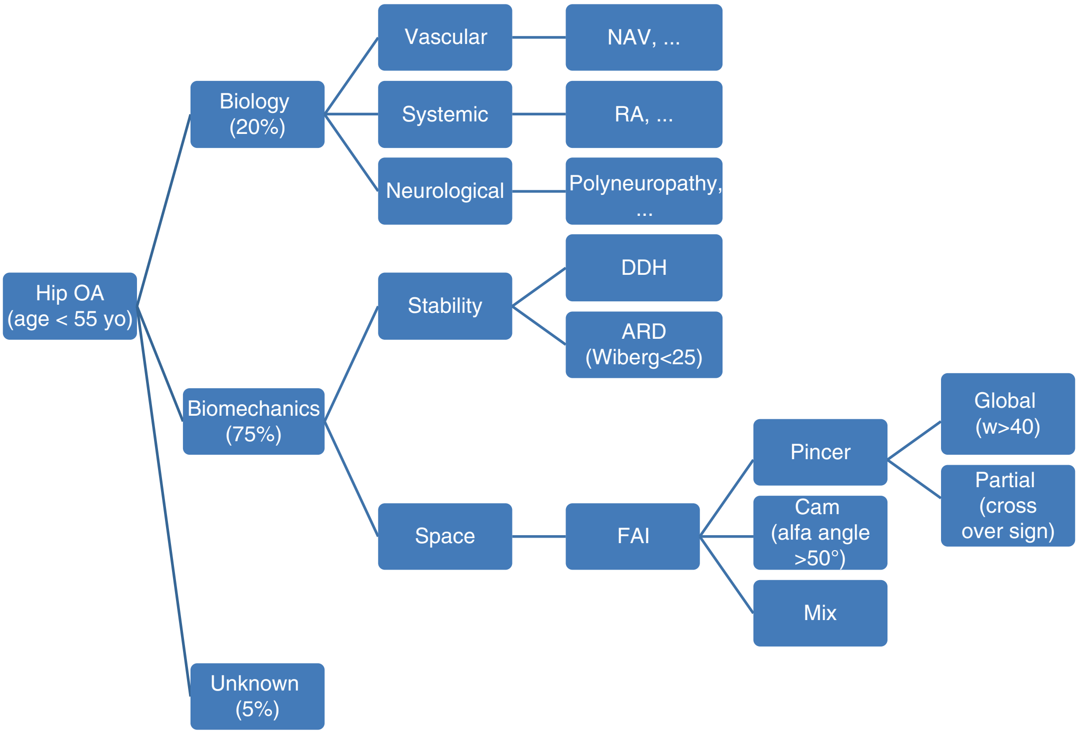


Graphic 18.1 Aetiology of hip osteoarthritis in young adults (younger than 55 years). (Adapted from Hofmann S, Tschauner Ch, Graf R. Mechanical Causes Of Osteoarthritis In Young Adults. Hip International 2003)

kinematics, like femoral or pelvic osteotomies. Current strategies are periacetabular osteotomy for conflicts of stability and osteoplasty for conflicts of space to restore biomechanics parameters of normal kinematics (Wiberg angle, Alfa angle, Tönnis angle and others).

2. Improvement of Biology. DJD is not a problem related to joint cartilage but to the entire joint: capsule, synovia, labrum, bone and cartilage are involved in DJD. The biological ambient seems to play a role, which can justify strategies like PRP, mononuclear concentrate from bone marrow, stem cells.
3. Protection, repair or restoration of damaged structures due to abnormal biomechanics, mainly labral structure and hyaline cartilage.

The cornerstone of hip preserving surgery is the *management of hyaline acetabular cartilage lesions*. In conflicts of stability, there is increased peak stress in the cartilage due to the small area of contact, and that leads to a progressive and global cartilage pathology following the classical sequence of cartilage damage of any diarthrodial joint [5]. Protection of cartilage damage is achieved through labral repair and increase of contact area, possible thanks to of reorientation osteotomies of the acetabular surface. When adult residual dysplasia (ARD) is presented with chondral damage, joint replacement should be considered since secondary osteoarthritis is present for sure.

Conflicts of space have a different pathophysiology. Pincer femoroacetabular syndrome (FAIS) produces an abnormal compressive force between femoral neck and acetabular rim, which produces labral damage by an inflammatory process and mechanical destruction, and the progression of the disease will produce secondary destruction of peripheral acetabular hyaline cartilage [6].

Cam and mix FAI produce a shear force in the acetabular rim. That shear force will produce a chondrolabral lesion, with a solution of continuity between labrum and hyaline cartilage, and secondary labral detachment (healthy labrum, detached from the bone) that usually affects 2/3 of labral attachment on the articular side, since the residual 1/3 on the capsular side correspond to the fibrous portion of the labrum, which supply vasculoner-

Fig. 18.1 Labrum looks well attached from capsular side in cam FAIS. Right hip without traction, scope at mid-anterior distal portal

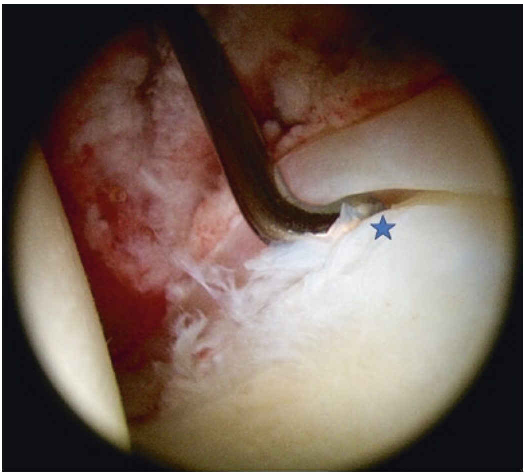


Fig. 18.2 Labrum has a good tension with probe, but there is a loss of continuity of chondrolabral union

Fig. 18.3 Sublabral sulcus on anterolateral area of left hip from anterolateral portal

vous structures to the labrum, but without participation in joint biomechanics. That explains why usually is observed a normal labrum from the capsular side but a detached one from the joint side in FAIS (Fig. 18.1).

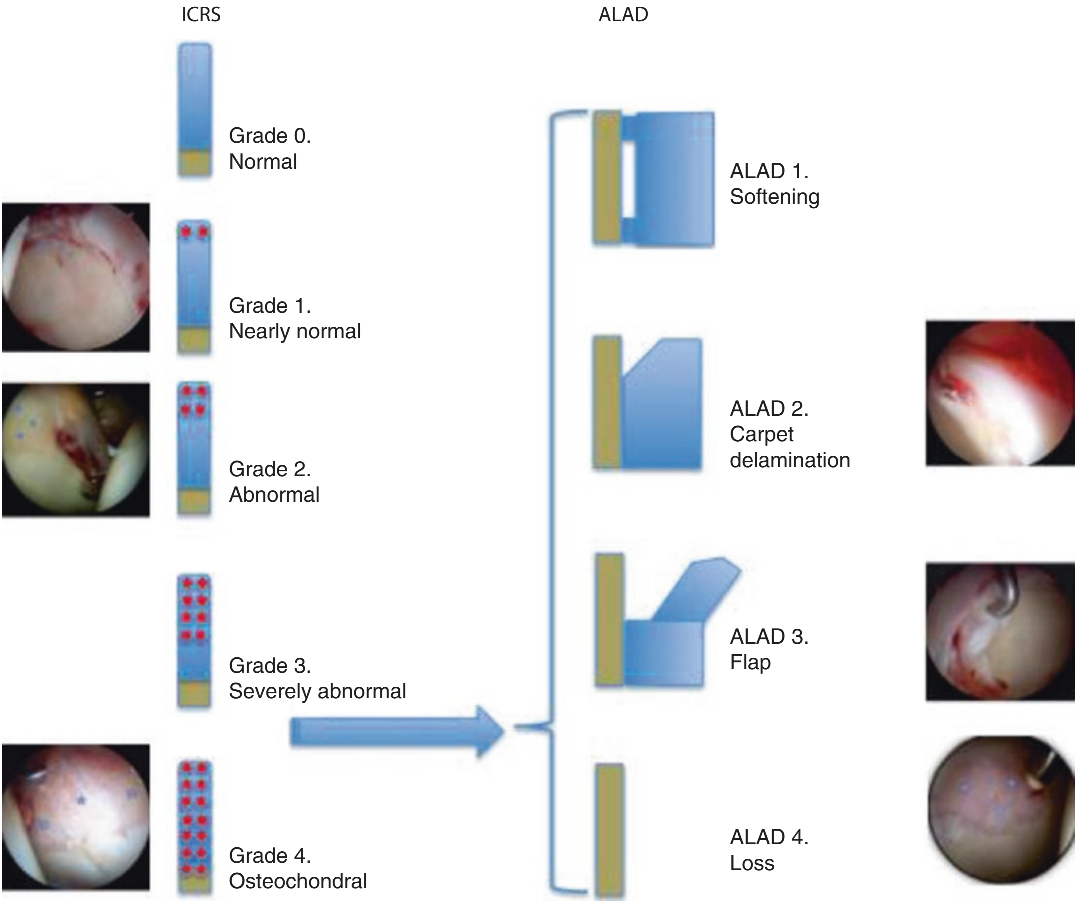
Loss of chondrolabral continuity is the first step in the pathophysiology as shown in Fig. 18.2, but it is not a definitive one since it does not change kinematics nor kinetics of the joint. In fact, there is a variation of normal anatomy of the hip where there is a *sublabral sulcus*, a physiologic loss of continuity of cartilage and labrum, and it does not represent a problem for the joint biomechanics. Lack of inflammatory signs or insufficiency of labral structure can help to identify that variation of normal anatomy (see Fig. 18.3).

Progression of that shear force will detach labrum from bony insertion and acetabular cartilage from the subchondral bone. That will break the hip joint seal, and the protection of hip biomechanics is compromised [7]. Sometimes the chondrolabral junction is preserved (in the initial phase of FAIS physiopathology), and a particular pattern of cartilage damage could be seen, the so-called bubble lesion, where chondrolabral union is still preserved but the cartilage is detached from the subchondral bone. Progression of the pathology will finally produce a chondrolabral lesion, and a free edge of stable cartilage could be seen, the so-called pocket lesion of acetabular cartilage, with a healthy and stable edge, but completely detached from the mineral layer of hyaline cartilage. A carpet lesion mechanism is advised since the detachment of cartilage can be huge while the macroscopic image of the joint by magnetic resonance (MR) or by direct visualization in hip arthroscopy remains normal. Progression of the lesion will take to destruction of that unstable cartilage, with flaps and progression of chondral damage. The frontier between this chondral damage and hip osteoarthritis and the no return point is not easy to define.

It is important to understand that acetabular chondral lesion and osteoarthritis do not have a linear correlation. DJD is a problem related to the whole joint and not just to the hyaline cartilage; that is why in some patients, big subchondral bone cysts and osteophyte formation are not necessarily associated with extended articular joint cartilage destruction. However, cartilage damage is usually associated with progression of osteoarthritis, being the cornerstone of joint preserving surgery limits.

18.2 Cartilage Lesions Classification

Classification is a process related to categorization that aims to establish prognostic factors and develop a therapeutic scheme. International Cartilage Repair Society (ICRS) classification is currently used as the international standard for hyaline cartilage repair strategies. However, cartilage physiopathology associated with FAIS is completely different from cartilage damage associated with overload, trauma or degenerative processes that affect any diarthrodial joint. Shear forces in the acetabular rim produce a particular lesion of hyaline cartilage, which is classified directly as advanced stages of ICRS classification without passing through previous ones. ALAD classification is frequently used for acetabular hyaline cartilage lesions associated with FAIS, responds to a grade 3 of ICRS and is better used to assess surgical options together with the extension of the damaged cartilage. Graphic 18.2 shows the correlation between both classifications.



Graphic 18.2 Cartilage damage classification

18.3 Algorithms for Treatment of Chondral Lesions

Aetiology and physiopathology of chondral damage should be identified to plan an adequate surgical option to treat it. MR is always necessary to screen any sign of osteoarthritis, and treatment of chondral lesions can be planned only in joints without DJD. Tönnis classification is frequently used to assess the degree of DJD present, but its usefulness has been questioned, and proper evaluation of MR (and not only radiology) is strongly recommended [8].

18.3.1 Pincer FAIS

Acetabuloplasty of excessive anterior wall protrusion with labral reattachment or restoration will usually restore biomechanics, and the area of cartilage destruction corresponds to the area of bone resection, as seen in Fig. 18.4a, b.

18.3.2 Cam and Mix FAIS

Initial chondrolabral lesion and some ALAD 1 with small area of acetabular cartilage lesion (less than 2 cm) can be addressed by labral reattachment and chondral debridement as seen in Fig. 18.5.

Debridement should ideally include all unstable cartilage to avoid progression of chondral damage [9], but it is limited by the size of residual lesion, and good results are documented just for lesions smaller than 1.5 cm^2 [10].

Big lesions or mirror lesions at femoral size are usually seen in more advanced DJD, and preserving surgery is associated with bad results. Cartilage techniques are not recommended in this situation [11].

When faced with an acetabular chondral injury associated with FAIS between 1.5 and 6 cm^2, without associated signs of osteoarthritis, a treatment strategy for the chondral lesion should be considered. That strategy should

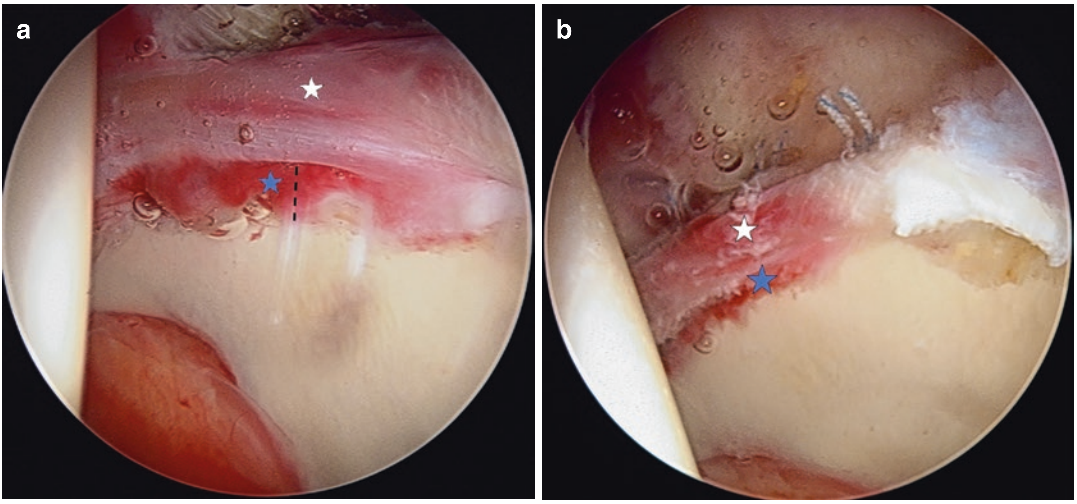


Fig. 18.4 (**a**, **b**) Pincer FAIS of left hip from anterolateral portal, with traction. Figure 18.1a shows the initial case, with labral detachment and ALAD 1 in anterolateral acetabular cartilage rim. Figure 18.1b shows the result after rim resection of 2 mm and labral reattachment with bone anchors. White star shows damaged labrum with swollen rim. Blue star shows damaged peripheral cartilage before and after rim resection of anterior acetabular wall. The damaged area of cartilage is resected with pincer resection

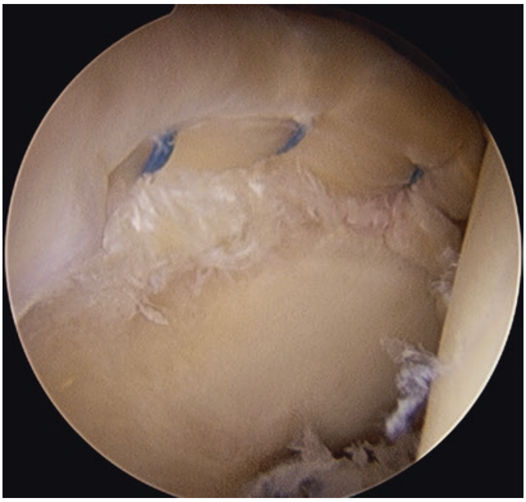


Fig. 18.5 Labral reattachment with limited debridement of unstable chondral edge damaged in a left hip treated for cam FAIS

always consider: (a) improvement of biomechanics (femoroplasty, acetabuloplasty and labral reattachment or reconstruction); (b) cell therapy, which can be done with stem cells or chondrocytes; (c) proper rehabilitation, with a long period of joint protection and delay of contact sports.

18.4 Marrow-Based Strategy

The major component of articular cartilage is water (75%) and to a lesser extent chondrocytes, proteoglycans and collagen, mostly type II. It is an avascular, aneural and alymphatic structure, and therefore with little capacity for regeneration by itself. These characteristics suppose a completely different biologic reparative response in comparison with other tissues. While in a vascular tissue, a three-phase response composed of necrosis, inflammation and repair is performed; in articular cartilage, a single-phase of necrosis is observed, without subsequent inflammatory exudate [12]. Deeper to the articular cartilage we find the subchondral bone, divided into the subchondral bone plate (cortical) and subchondral trabecular bone. These layers are a source of new blood vessels, and when the lesion affects them, the three reparative phases previously commented take place. In order to stimulate this subchondral bone, the microfracture technique was described, which is a ‘marrow-based strategy’, with an influx of marrow substrates (mesenchymal stromal cells or fibroblasts, growth factors and cytokines) to repopulate the lesion [13]. Microfractures will form a rough surface that will facilitate the containment of the marrow clot that will form a scaffold necessary for the repair. The inflammatory phase is led by the new vascularization, which will increase its permeability and facilitate exudation, which will help clot formation. The pluripotent cells will proliferate and differentiate into fibroblasts and chondroblasts, which are necessary for repair and responsible for the formation of repair cartilage. The final result will be the formation of fibrocartilage with mainly collagen type I (50%), fibrous tissue (30%) and hyaline cartilage (20%). The resulting fibrohyaline cartilage filling the initial lesion produces a decrease of forces on the intact cartilage but offers a decreased stiffness and resistance compared to hyaline cartilage.

Microfracture is the best known bone marrow-based strategy that is limited by size, with the results being worse when the size exceeds 2.5 cm^2 [14]. Enhanced microfractures with chitosan or with collagen membrane, named autologous matrix-induced chondroplasty (AMIC), have been proposed to improve mid- and long-term results in larger lesions [9, 15]. Knee clinical studies support the benefits of microfracture and chitosan with respect to microfracture alone for lesions larger than 2.5 cm^2 [16].

18.5 Surgical Technique

Hip arthroscopic surgery is performed in traction table, with controlled distraction of the joint to allow proper work in the acetabulum area. Standard anterolateral and mid-anterior distal portals are used as viewing and working portals, respectively. Once chondral lesion is confirmed, proper debridement is performed prior to final surgical technique decision.

18.5.1 Debridement

It is very important to achieve a good debridement, that is, remotion of all the unstable cartilage to avoid a mechanical evolution of chondral damage.

Four steps had been identified for a proper debridement [17]:

(a) Washing the joint
(b) Removal of loose bodies
(c) Removal of unstable cartilage
(d) Removal of mineralized layer

Once proper debridement is obtained, and acetabular wall resection in pincer or mix FAIS when indicated is performed, measurement of final chondral defect can be conducted to decide the final cartilage technique to be performed. Figure 18.6a, b show how difficult is to really size the lesion until proper debridement is performed.

18.5.2 Microfracture

For lesions between 1.5 and 2.5 cm^2, microfracture alone can be performed with good results in long-term follow-up [18], but it is important to follow all the steps described by Steadman [19, 20].

(a) Perform healthy, vertical and stable margins of the lesion.
(b) Contained lesion. This is a very important step. Since acetabular chondral lesions are usually at acetabular rim, proper labral reattachment is very important to obtain a contained lesion, able to stabilize the blood clot.
(c) Debridement of calcified layer. Curettes will be used to completely remove the calcified layer, being careful not to violate the subchondral bone, as seen in Fig. 18.7.
(d) Microfracture of the exposed area is then microfractured with 60–90° arthroscopic awls, penetrating the subchondral bone approximately 3 mm depth and every 3 mm until covering the entire surface (Fig. 18.8).
(e) Confirm adequate penetration of the subchondral bone by observing bone marrow bleeding and/or fat droplets from the microfractured holes after reduction of the irrigation pressure (Fig. 18.9).

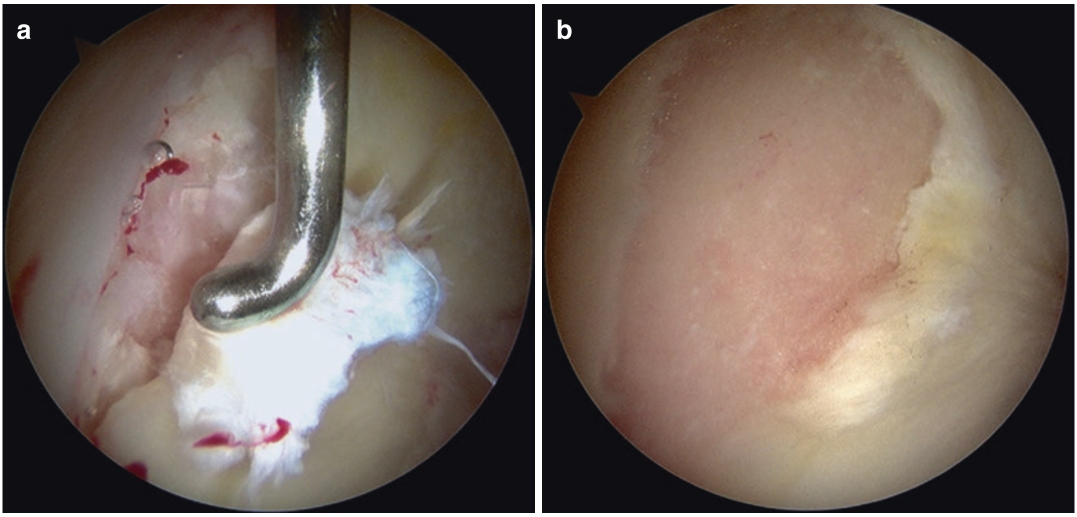


Fig. 18.6 (**a**, **b**) Right hip view from anterolateral portal under traction. Figure 18.5a shows the initial unstable flap (ALAD 3), and Fig. 18.5b shows the final chondral damage after removing the unstable cartilage

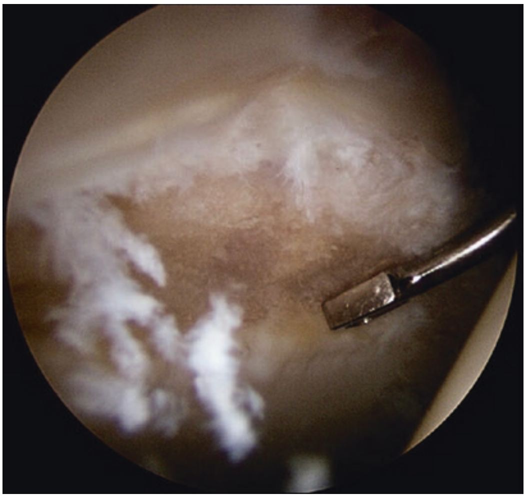


Fig. 18.7 Left hip view from anterolateral portal under traction. Curettes are used to remove calcified layer, preserving subchondral bone

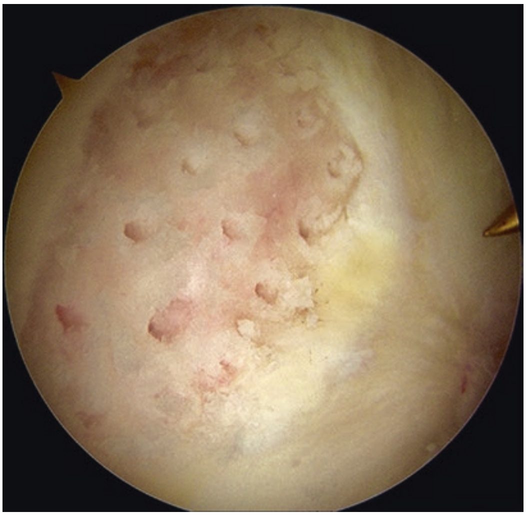


Fig. 18.8 Same hip than Fig. 18.6 after microfracture

18.5.3 Chitosan Addition

Chitosan mixture is prepared according to the manufacturer's instructions as previously described [21]. The application is performed, as seen in Fig. 18.10, as follows:

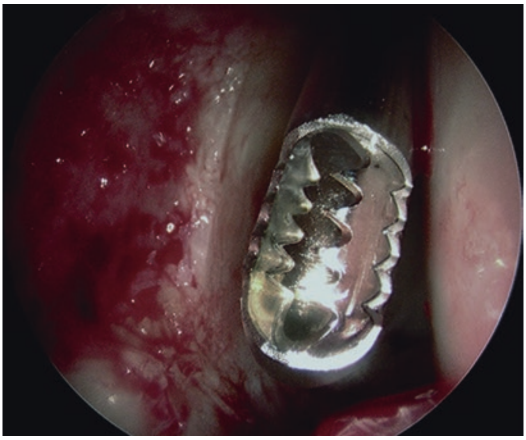


Fig. 18.9 Same hip after drainage of fluid. Blood clot is formed in the exposed area

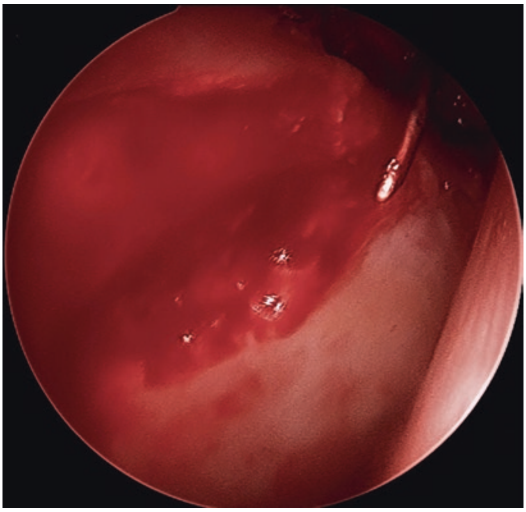


Fig. 18.10 Same hip after addition of chitosan

(a) Drain the joint. Stop fluid and drain the joint until completely dry area is obtained at chondral defect.

(b) Delivery of the mixture. In a dropwise manner, using large 18G needles and without overfilling the exposed area.

18.6 Postoperative Care

Rehabilitation follows a standard protocol of FAIS in terms of movement and muscle balance, but weight-bearing protection is mandatory. Proprioceptive deambulation assisted with crutches for 6 weeks and avoiding contact sports during the first year are strongly recommended.

Follow-up of cartilage reparative techniques can only be properly done by T2 mapping or dGEMRIC images, and clinical symptoms are not a good reference for assessing proper development of reparative cartilage; there are no nerves to help the patient to protect from excessive pressure.

Tips and Tricks of Chondral Strategies

1. Preoperatively, always perform a good quality MR or MRA to suspect the cartilage lesion in painful hips related to abnormal biomechanics.
2. Discuss cartilage strategies with your patient. Evidence and rehabilitation requirements must be known and accepted by the patient before surgery. Sometimes your best option does not suit with patient's expectations.
3. Debridement of unstable cartilage should be performed before labral reattachment. It can help to define the amount of acetabuloplasty to be done, and debridement through labral detached can be helpful.
4. After debridement of unstable cartilage, decide final cartilage strategy according to patient's expectations (discussed pre-op), characteristics (age, activity, weight, etc.) and cartilage lesion.
5. Abnormal residual cartilage (grade 2 or 3 of residual acetabular cartilage) or any mirror lesion on femoral head should make you abort any regenerative technique, and debridement should be the only strategy for cartilage lesions.
6. When bone marrow strategy is decided, proper cartilage resection, with healthy borders and geographical shape, should be performed before measuring cartilage defect.
7. Always decide the enhancement of bone marrow technique after proper cartilage resection. Chitosan should be then decided and bring it outside the fridge to achieve an ambient temperature before its use.
8. Microfracture's awls should be very well known by the surgeon. Revision of the tip should be performed regularly.
9. Debridement of calcified layer is very important. If grooves instead of holes are achieved with your awl, suspect it is not properly debrided.
10. Addition of chitosan will be performed at the end of your surgery, after cam resection and capsular closure. That will help to drain the joint.

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Open Femoral Head Mosaicplasty

19

Augustin Le Viguelloux, Willaume Guicherd,
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19.1 Introduction

Osteochondral lesions of the femoral head are a challenging pathology of the hip. Cartilage does not regenerate, and its lesions gradually evolve towards osteoarthritis [1, 2]. In young patients, different surgical strategies have been proposed to repair chondral lesions and restore articular surfaces, including microfracture [3–6] and autologous chondrocytes implantation [7, 8], but these techniques are inadequate when the underlying bone is involved. Thus, osteochondral autograft or allograft transplantation has been described [9, 10].

The authors' choice for the treatment of osteochondral injury of the femoral head is an open femoral mosaicplasty using osteochondral autograft from the ipsilateral femoral head performed by a minimally invasive Hueter approach.

19.2 Surgical Technique

19.2.1 Installation

The patient is placed supine on an orthopaedic table, both legs with a slight traction. The post needs to be large to avoid perineal lesions secondary to traction, and the foot is securely attached. The femur is placed in neutral rotation, patella facing up. After cutaneous preparation, an adhesive transparent dressing is placed (Fig. 19.1), in order to control the manipulation of the traction table at any time during the surgery.

19.2.2 Modified Anterior Hueter Approach

The cutaneous landmarks of the incision start one finger under and lateral to the anterosuperior iliac spine, and go 8–10 cm distally and slightly laterally (Fig. 19.2a). Care is taken not to damage the lateral femoral cutaneous nerve (LFCN), and so the fascia of the tensor of the fascia lata (TFL) is opened to pass through the natural space between TFL and sartorius, leaving the LFCN medially. The space is enlarged (Fig. 19.2b) to reach the anterior circumflex artery (Fig. 19.2c). After ligature and section of the artery, a fat tissue triangle is reached, just under the artery, between psoas medially, gluteus minimus superiorly and vastus

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Fig. 19.1 Orthopaedic table. Transparent dressing. Left lower limb neutrally positioned

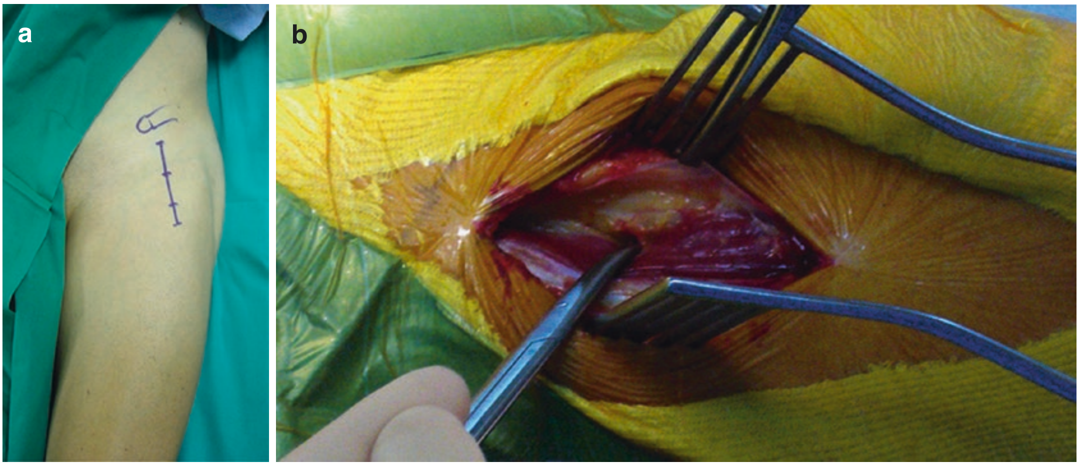

Fig. 19.2 Left hip anterior Hueter approach: (**a**) cutaneous landmarks of the incision; (**b**) natural space between TFL and sartorius; (**c**) anterior circumflex artery; (**d**) anterior capsule exposition

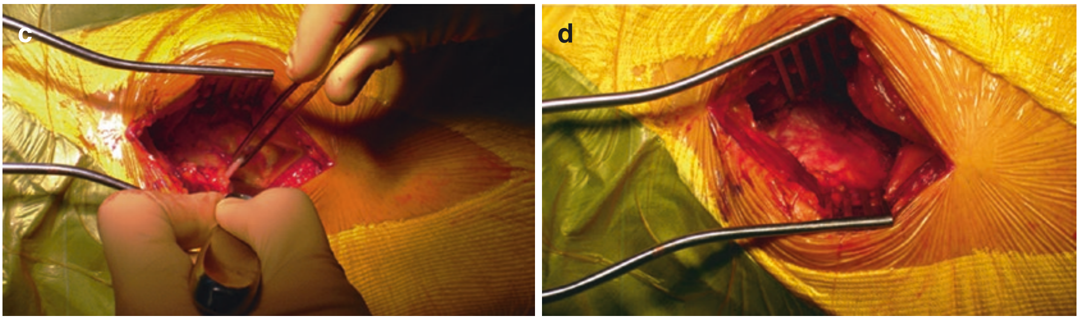

Fig. 19.2 (continued)

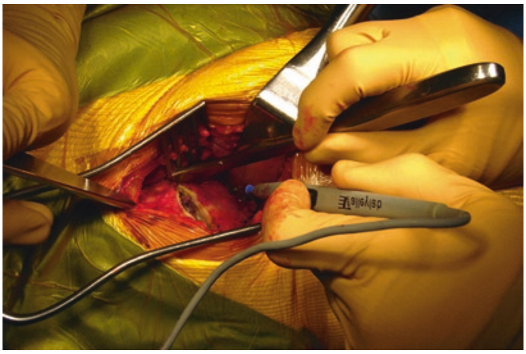

Fig. 19.3 Left hip. Inversed T-shaped capsulotomy

lateralis inferiorly. This fat tissue is excised to expose the anterior capsule (Fig. 19.2d).

An inverted T-shaped capsulotomy is then performed, with close attention to the chondral surface and labrum (Fig. 19.3).

19.2.3 Femoral Head Dislocation

A capsular grip is placed on each part of the incised capsule to expose the femoral neck with a McKey or a Charnley retractor. Traction and internal rotation are then applied to the lower limb resulting in decoaptation and anterior opening of the joint. A pair of scissors can be inserted in the joint, with the aim of releasing the ligamentum teres (LT) by a blind cut, located under the femoral head (Fig. 19.4). The resistance of the ligamentum is felt by the scissors, and the cut is difficult. Fluoroscopy can help at this time of the procedure.

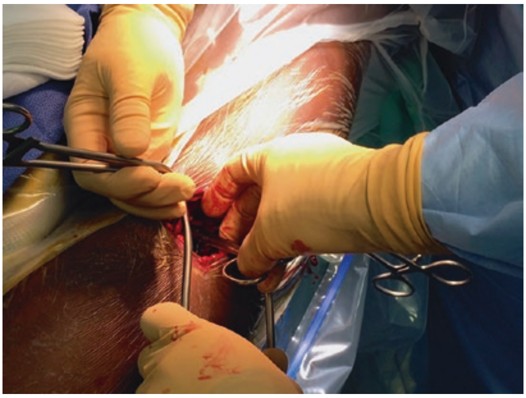

Fig. 19.4 Left hip. Traction on the lower limb allows a pair of scissors to go thru the joint and release the ligamentum teres tendon

Once the LT is released, the femoral head is ready for dislocation. The lower limb is positioned towards the ground in traction, adduction and maximum external rotation. A blunt hook is placed around the femoral neck, and the surgeon pulls the hook sharply upwards and to the side, while the assistant is slowly releasing traction to expel the femoral head from the acetabulum. This is the most difficult part of the procedure, the dislocation of the hip without damaging the cartilage being not easy to achieve. In case of failure, before another trial, the release of the LT should be checked, and the anterior capsule should be released on the acetabular part, taking care of the labrum.

To dislocate the hip

- Inverted T-shaped capsulotomy
- Traction and internal rotation
- Ligamentum teres section
- Hyperextension, adduction and external rotation
- Slow traction release while pulling the femoral head out
- No traction at the end of the procedure

19.2.4 Osteochondral Lesion Preparation

Once the femoral head dislocated, the apex of the femoral head is perfectly exposed by keeping the position of the lower limb in external rotation, hyperextension and adduction, but without any traction (Fig. 19.5).

Once debridement of the osteochondral lesion is performed to safe margin, the size of the defect is measured. The number and size of plugs needed to fill the lesion can be assessed (Fig. 19.6). We recommend the use of large diameter plugs, with a minimum diameter of 6 mm, to limit the risk of collapse of the plug during insertion.

With the mosaicplasty set you are used to, several holes of the desired diameter are performed in the defect, perpendicularly and 15 mm to maximum 20 mm deep to the femoral head surface. The deeper you dig, the more you have to space the plugins because of the convergence related to the sphericity of the femoral head. The removed bone is saved to fill in the donor site afterwards (Fig. 19.7).

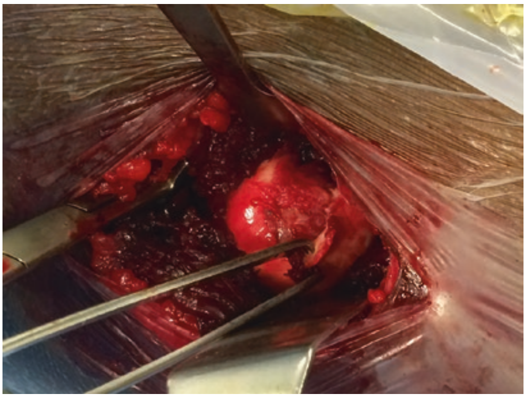

Fig. 19.5 Left hip. Perfect visualization of the femoral head dislocated in hyperextension, external rotation and adduction

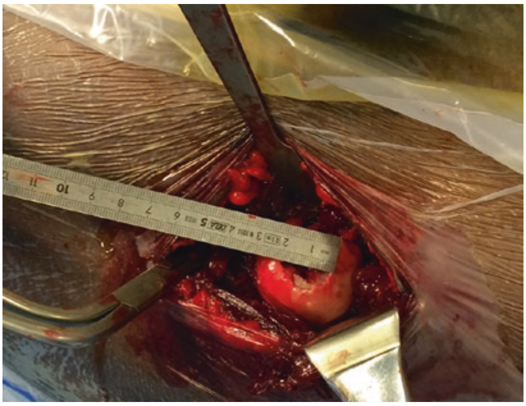

Fig. 19.6 Left hip. Measuring the osteochondral defect

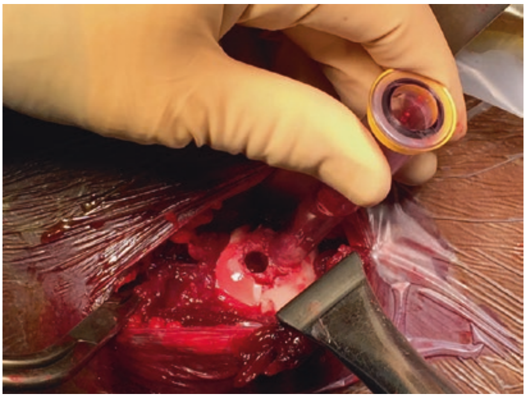

Fig. 19.7 Left hip. Preparation of the osteochondral lesion. In this case, each hole is 8 mm in diameter and 15 mm in depth

19.2.5 Harvesting the Plugs

The plugs can be harvested on the anterosuperior part of the femoral head–neck junction, as close as possible to the head, if the there is a cam lesion with good cartilage coverage. Otherwise, the harvest is performed in the non-weight-bearing lower part of the femoral head (Fig. 19.8).

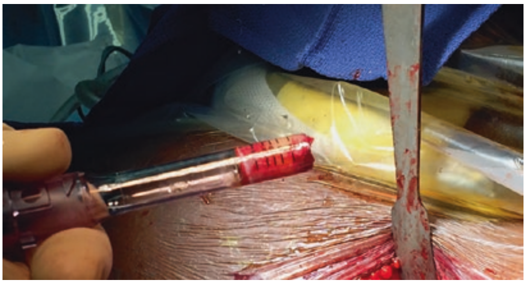

Fig. 19.8 Left hip. Harvested plug in the COR disposable instrumentation (Depuy-Mitek)

Once all the plugs have been harvested, the cam deformity, if present, can be resected, and the holes are filled with bone removed from the osteochondral lesion and resection of the cam.

Harvesting the plugs
- Large diameter (6–10 mm)
- No more than 20 mm deep
- Localization = anterior head–neck junction or inferior part of the head

19.2.6 Positioning the Plugs

Each plug is then placed in its prepared hole in the osteochondral defect with a non-aggressive pusher. The thickness of the plugs has to be sufficient (should be 3 mm longer than the prepared holes) to get the plug flush with adjacent cartilage of the femoral head (Fig. 19.9). If the plug is too short, fill a part of the hole with the remaining bone before placing the plug.

Once the good fit of the plugs and the good head sphericity is obtained, the femoral head can be reduced. For a soft reduction, traction is applied again slowly in the lower limb, keeping external rotation and adduction. The femoral head is accompanied with the hook around the neck. The head should automatically return to the acetabulum with traction. Otherwise, keep traction and reduce adduction and external rotation once the head is in front of the acetabulum.

After reduction, check that no soft tissues have become trapped in the acetabulum during this manoeuvre by maintaining traction and applying internal rotation. If needed, a labral partial resection or suture can be performed at this time, ideally under arthroscopic assistance.

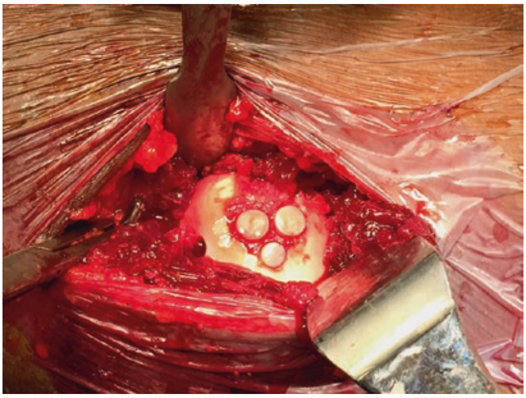

Fig. 19.9 Left hip. Grafted area at the end of the procedure. Two 8 mm plugs and one 6 mm plug are in place

After joint lavage, the capsule can be closed side to side. No drain is mandatory, and the fascia lata and other layers are closed.

19.2.7 Post-Operative Rehabilitation

Toe-touch weight-bearing on the operated limb is allowed for the first 6 weeks and then progressed to total weight-bearing as tolerated. Passive flexion and joint mobilisation are to begin immediately. Active sagittal plane motion exercises are allowed after the first 3 weeks.

Difficult steps of the procedure
- Femoral head dislocation
- Positioning the plugs
- Getting the plugs flush with adjacent cartilage
- Soft reduction of the femoral head
- Labral suture by this approach

19.3 Results of the Technique in a Multicentric Study in France

Osteochondral defects of the femoral head lead to early osteoarthritis. Currently, their treatment does not reach consensus [11–14]. Even though the literature is poor, hip mosaicplasty appears to be an effective technique to treat these lesions in a conservative way, thus avoiding THA in young and active patients. [1, 2, 15–22]. In a recent multicentric study [23], we reported the early results of 22 patients treated for an osteochondral defect of the femoral head using this technique. We found satisfactory results with 91% patients satisfied or very satisfied and a significant improvement in mHHS score of 32.2 (±14.1) and WOMAC score of 35.5 (±16.0). One patient developed osteoarthritis treated with THA and 2 patients needed arthroscopy to improve cam-type correction, which is a common reason for repeated hip arthroscopy [24–26].

Despite few limitations, such as the retrospective aspect, the minor variation in surgical technique and the small cohort of patients, this study is the most important cohort for hip mosaicplasty, yielding encouraging results with almost no complications of the technique.

19.4 Alternative Conservative Surgical Techniques

19.4.1 Surgical Approach

Currently, trochanterotomy sparing the blood supply and the external rotators, according to Ganz et al. [27], is the most common approach for hip mosaicplasty [1, 2, 15, 18, 28]. But it remains a very demanding approach with risks of trochanteric bursitis and non-union of the great trochanter [2, 15].

Hueter approach appears to be the less invasive approach for surgical dislocation [29]:

- External rotators are preserved, as well as tendons and muscles around the hip.
- Vascularization of the femoral head is protected since the medial femoral circumflex artery is preserved [30, 31].

However, a recent study shows how to preserve the blood supply with a modified posterior approach [32].

The last possible approach for this indication is the Watson–Jones procedure, used in the study by Louahem, the patient being placed in a supine position [21].

19.4.2 Donor Site

Most of the studies published to date have used ipsilateral knee autograft [17–19, 21, 22], while we described, with some other studies, the use of autologous femoral head autograft as donor site [1, 2, 28, 33]. In our experience, autografts from lower part of the femoral head or from the cam deformity [34] were of good quality with no issues in harvesting or fixation. If the knee is needed as a donor site, it increases the morbidity of the procedure by affecting a healthy joint, with the risk of creating stiffness and pain in this joint [1, 35].

19.4.3 Reverse Mosaicplasty Under Arthroscopy

The use of arthroscopy for mosaicplasty, as described by Petit and Philippon [34], is very attractive but very challenging. In addition, it has several drawbacks:

- It allows the insertion of only one graft as related in different studies and case report [20, 22, 36].
- A perforation is needed from the lateral cortex of the femur.
- The perforation needs to be in the right direction and angle to be perpendicular to the femoral head surface, in order to insert your plug flush with adjacent cartilage, which is clearly difficult and not always possible.
- The fixation of the graft requires material placed in the femoral head.
- The donor site is mandatory in the knee with the morbidity described previously.

19.5 Conclusion

Open femoral head mosaicplasty is a challenging conservative technique. The purpose of this chapter is to introduce you to the main steps as well as tips and tricks to make this operation a success in your hands, but it will not replace the need to train with an experienced surgeon before beginning this difficult procedure.

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Part V

Tendons

20

Endoscopic Trochanteric Bursectomy

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20.1 Introduction

Trochanteric bursitis or greater trochanteric bursitis (GTB) is a common condition presenting to the orthopedist or family physician that can limit sports and/or daily activities [1, 2]. Middle-aged women are typically affected, but the incidence is increasing in younger patients, particularly in runners [1, 3].

Inflammation of the bursa might result from acute direct trauma or, more commonly, repetitive microtrauma between the greater trochanter (GT) and the iliotibial band (ITB), such as during long-distance running or prolonged weight-bearing. Tendinopathy or tearing of surrounding musculature—namely, the gluteus medius and/or minimus—can also be associated. For those cases, the broader concept of greater trochanteric pain syndrome (GTPS) has been suggested [4].

The primary symptom is focal pain over the GT that occasionally radiates down to the lateral aspect of the thigh or to the buttock region, and that worsens with local palpation, prolonged standing activity or in the single-leg stance [4]. Side lying may be intolerable and subsequent reduction in physical activity can have significant health implications [5].

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20.2 Management

Most patients respond to the first line nonoperative measures such as rest, ice, stretching, and medications (nonsteroidal anti-inflammatory drugs and/or paracetamol). A more invasive conservative approach consisting of localized injections of anesthetic and corticosteroid combined with a physical therapy program focusing on improving hip control, with gluteal and abductor strengthening, can also be applied with successful results [6, 7].

Still, a small subset of patients experiences recalcitrant symptoms, for which surgical bursectomy may be indicated. Bursectomy was first described through open approach [8] and later arthroscopically [9–15] and has shown encouraging outcomes, with no major postoperative complications [4, 16]. Alternatives for such cases are scarce and yet to show reliable and effective results [17, 18].

20.3 Surgical Technique

20.3.1 Patient Positioning

Endoscopic bursectomy can be performed in lateral decubitus or supine. In our practice, arthroscopic bursectomy is usually performed concomitantly with other arthroscopic hip procedures, often with intra-articular procedures. Thus, we prefer the supine positioning with the patient on a traction table (but no traction is applied) and the affected leg should be allowed some degrees of motion, in particular abduction, to relax the surrounding soft tissues. Internal and external rotation can also be applied to increase exposure throughout the procedure.

20.3.2 Approach

In the advent of a combined approach with intra-articular procedures, the bursectomy is performed subsequently to the intra-articular procedures (Table 20.1). After routine preparation and hip draping, standard anterolateral (AL) and modified anterior portal (MA) are routinely utilized (Fig. 20.2). Through the AL portal and using a 70° arthroscope, diagnostic arthroscopy is performed to evaluate potential intracapsular pathology—femoroacetabular impingement, labral tears, chondral lesions—and the necessary therapeutic measures are taken.

Table 20.1 Pearls and pitfalls of arthroscopic bursectomy

Pearls	Pitfalls
• Use traction table for patient positioning, but leave room for some motion of the operated leg, particularly rotation • Intra-articular procedures should take place before the bursectomy to avoid difficulty in portal placement and entry • Radio frequency ablation should be used for hemostasis and excess fluid should be drained to avoid seroma and hematoma	• Sciatic nerve anatomic position should be kept in mind when debriding posterior structures, particularly with leg in internal rotation • Extravasation of fluid to the extra-articular soft tissues may make it hard to pass instruments intracapsularly, if bursectomy is performed first

20.3.3 Throcanteric Bursectomy

After addressing any potential intra-articular pathology, the procedure moves laterally to the area overlying the GT. The peritrochanteric space can be reached from the outside in—meaning that the ITB will be opened from the outside to reach the peritrochanteric space or this space can be reached directly with or without fluoroscopy. We prefer the direct approach with the use of fluoroscopy.

The MA portal is used to reach the surgical plane anteriorly, between the ITB and the hip abductors, creating space through irrigation and gaining access to the bursae and gluteus tendons. The ideal position of the trocar may be controlled under fluoroscopy (Fig. 20.1). The trocar is placed lateral to the greater trochanter and medial to the ITB just proximal to the vastus lateralis ridge. A 70° arthroscope is used throughout this procedure as well. Accessory portals in the safe zone can be established as needed to address the underlying

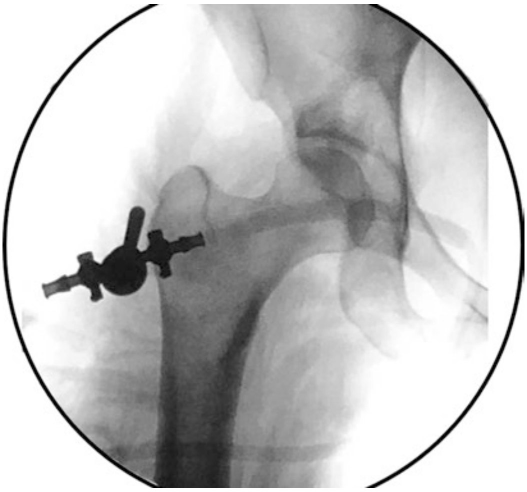

Fig. 20.1 Fluoroscopy view. Trocar positioning (slightly proximal and lateral to the vastus ridge between the ITB and the abductors)

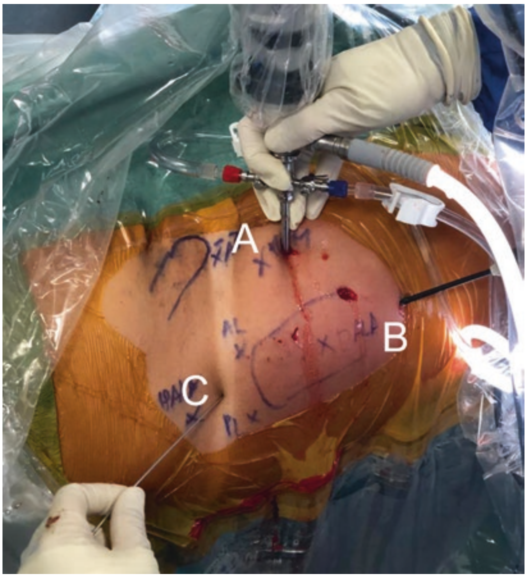

Fig. 20.2 Portal placement. (*A*) 70° arthroscope placed in MA portal "looking" proximally for establishment of the PALA portal. (*B*) DALA portal with vaporizer device. (*C*) PALA portal being established

pathology. Typically, a distal anterolateral accessory (DALA) portal is established 5–8 cm distally to the AL under direct visualization, while a proximal anterolateral accessory (PALA) portal is also established under direct visualization (Fig. 20.2). The PALA portal provides optimal access to the proximal area of the surgical field and is especially important if addressing gluteal pathology. Both portals are aligned with the femur. With the trocar in place, a 70° arthroscope is placed which should be in a plane limited by the ITB laterally, the gluteus maximus tendon distally, the vastus lateralis medially, the gluteus medius proximally and medially, and tensor fasciae latae proximally and laterally.

Once the visualization portal is established, our attention is directed distally. Oftentimes, the inflammation is abundant and hinders visualization, so a reference is necessary to guide us through the remaining procedure. At this stage, we seek a constant anatomical feature that is the tendon of the direct head of the gluteus maximus, located distally in the field (Fig. 20.3b). Following its identification, we can trace it until the point where it goes underneath the vastus lateralis (Fig. 20.3a). The ITB can be visualized laterally (Fig. 20.3d).

An extensive debridement of the bursal tissue and fibrous adhesions is performed proximally with an arthroscopic shaver and radio frequency ablator, always visualizing the vastus lateralis until reaching the vastus ridge. Debridement proceeds over the gluteus medius tendon (Fig. 20.4c). The gluteus minimus can be visualized if necessary—

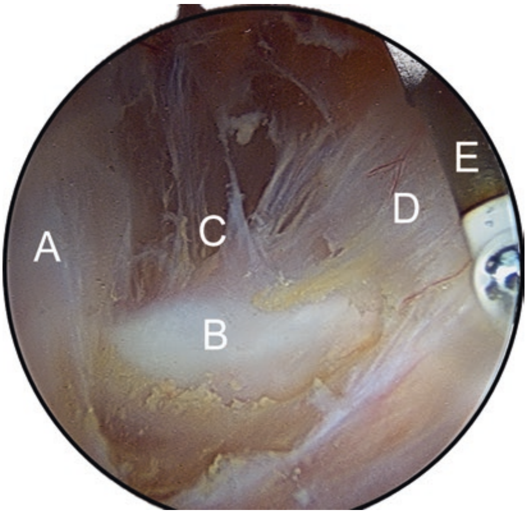

Fig. 20.3 Distal view. (*A*) Vastus lateralis, (*B*) gluteus maximus tendon, (*C*) bursal tissue, (*D*) iliotibial tract, (*E*) electrocauterizer

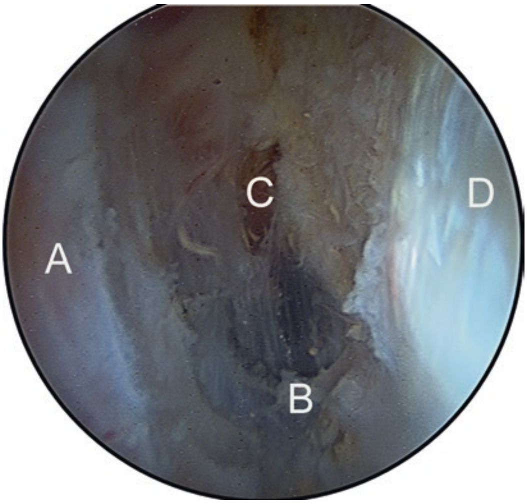

Fig. 20.4 Proximal view. (*A*) iliotibial tract, (*B*) bursal tissue (subgluteus maximus bursa), (*C*) gluteus medius (muscle fibers), (*D*) gluteus medius (tendon)

these are separated through the bare area. The patient's foot may be internally and externally rotated in order to gain access to the more posterior or anterior areas of peritrochanteric space, respectively. The superficial and deep subgluteus maximus bursae, the gluteofemoral bursa, and the secondary subgluteus maximus bursa can be reached in this space. The sciatic nerve should not be at risk as long as deep dissection of posterior tissues is avoided, particularly in extreme internal rotation and through the short external rotators of the hip (Table 20.1).

Other procedures in the peritrochanteric space can the performed at this stage such as those addressing gluteal pathologies. A partial release of the ITB may be performed, if desired. We typically perform ITB release if there is clinical evidence of external snapping hip. We also carry out the procedure from the inside out in a cruciform fashion after searching for an area of fraying within the ITB extending the longitudinal cut as distally as the gluteus maximus tendon and the crossing cut posteriorly until the end of the ITB and muscle fibers are visible.

20.3.4 Closure and Discharge

The surgeon should be cautious to ensure adequate hemostasis and excess fluid drainage before closure, in order to avoid (minor) complications such as hematoma or seroma (Table 20.1). Long-acting local anesthetic may be injected into the portals for postoperative analgesia. Patients can be discharged in the same day, with exception to those in which osteoplasty is performed, which we usually discharge the following day. If intra-articular procedures were performed, indomethacin is prescribed to reduce heterotopic ossification.

20.4 Postoperative Rehabilitation

Crutches are prescribed for comfort, as the patient is allowed to progressively bear weight as tolerated. Early gentle, passive and active hip range of motion should be encouraged, except for flexion or abduction above 90° if labral pathology was addressed or capsular closure was ensued. A specific physical therapy program should be initiated aiming the strengthening of the hip muscle and range of motion restoration.

20.5 Discussion

Notwithstanding the high incidence, a secure diagnosis of trochanteric bursitis may be challenging to achieve, particularly when considered under the "umbrella" of GTPS and the variability of pathological entities it entails. Deep palpation over the GT and the one-leg-stance test is very suggestive and usually reliable in the diagnosis; however, ultrasonography and magnetic resonance imaging can be helpful in excluding or revealing hidden pathology when the physician remains uncertain.

Even though nonsurgical management resolves the majority of GTPS when adequately prescribed and applied, recalcitrant cases might require a surgical solution. In this regard, outcomes for endoscopic bursectomy are generally favorable, with a quick and significant decrease in pain and function improvement that is sustained over time, with rare recurrences and no major complications.

There are a few studies reporting the results of endoscopic bursectomy for trochanteric bursitis. Larose et al. [13] described a reported decreased pain from 8.4 to 2.6 using the visual analog scale (VAS) and function improvement measured by the Hip Outcome Score (HOS) in a group of 38 patients with a minimum of 24 months of follow-up. The average HOS ADL subscale result was greater than 70% which demonstrates good functional outcome. In this cohort, 21% of the patients required a secondary surgical procedure for either intra-articular pathology, refractory bursitis or an abductor muscle tear, which highlights the importance of correctly identifying and concomitantly addressing these problems, to avoid unnecessary further procedures. Weise and colleagues [15] reported the results of endoscopic bursectomy on 37 patients at 12–48 months of follow-up and showed a similar decrease in pain from 7.2 to 3.8 using the VAS and an increase in function using the Japanese Orthopaedic Association score (from 40.5 at baseline to 72.6 at 25 months of follow-up). Four patients developed hematoma postoperatively but did not need any further interventions. Fox et al. [11] reported a 96% satisfaction rate at 5 years following bursectomy, with only 2 patients reporting recurrence of pain. Baker and collaborators [9] followed 20 patients for a mean of 26 months and described significant improvements in pain (7.2 to 3.1 in the VAS), with one minor postoperative complication (seroma) and one failure that was resolved with open bursectomy. All studies included patients with at least 6 months of failed conservative treatment.

20.6 Conclusion

Endoscopic bursectomy is a reliable and effective technique for recalcitrant GTB and is nowadays a preferred method over “open” bursectomy, with long-lasting benefits. It can—and should—be combined with further intra- or extra-articular arthroscopic hip procedures, as the broader GTPS should always be considered when approaching these patients.

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21

Iliotibial Band Release and Gluteus Maximus Tendon Release (Polesello)

Olivier May

Iliotibial band release and gluteus maximus tendon release has been described for external coxa saltans (*dancer's hip*) or external snapping hips. Symptoms are commonly described as an audible or palpable snapping sensation that is heard during the movement of the hip joint [1–3]. This syndrome can occur during daily activities, but most of the time, external snapping hips occur during athletic activities that require flexion and extension.

It is most commonly attributed to the iliotibial band moving over the greater trochanter during hip movements in flexion, extension, and external or internal rotation and is most commonly an overuse phenomenon.

Most of the time no etiology is uncovered at all, resulting in an idiopathic classification [4] but some anatomical situations may predispose to coxa saltans: increased distance between the greater trochanters with narrow bi-iliac width (prominent greater trochanters), iliotibial band tightness, shorter muscle or tendon lengths, and muscle tightness.

In certain situation, snapping hip can be induced: increased femoral offset after THR, direct trauma on the greater trochanter with lesions of the iliotibial band, surgical procedures, intramuscular injection into the gluteus maximus…

Regarding epidemiology, it has been described [5] that approximately 5–10% of the population is affected by coxa saltans, with the majority of patients experiencing painless snapping. The prevalence appears to be slightly higher in women than in men. The groups typically affected include those who do repetitive extreme hip motions, including competitive and recreational ballet dancers, weight lifters, soccer players, and runners. Of the competitive ballet dancers, almost 90% reported symptoms of snapping hip syndrome and 80% had bilateral involvement.

Physical examination is the key point of the diagnosis: the patient can point the area that is painful upon snapping on the great trochanter. The pain is due to greater trochanter bursitis, abductor tendon pathology, or inflammation of the iliotibial band. Symptoms develop and increase over a long period of time, sometimes years. Patients are most of the time able to recreate the snap examinator and report sensation of subluxation of the hip. It is important to notice a difference between active and passive examination of the hip. The snap is reproduced during active femoral rotation and or flexion but not during passive. Examinator can palpate the snapping phenomenon under the patient's skin or even visualize it. Ober test can be done to test the iliotibial band tightness. The role of physical examination is also to exclude other sanpping hips: internal (psoas tendon rolling over the medial

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fibers of the iliacus muscle), posterior (hamstring tendon rolling over the ischial tuberosity).

Even if the diagnosis is set up with physical examination, imaging can be used to rule out other hip pathologies. Ultrasonography can be used to confirm the snapping of the iliotibial band over the greater trochanter, especially dynamic. However, this exam is especially interesting to search associated tendinitis, bursitis, or muscle tears. X-rays should be done to search anatomical situations that may predispose to coxa saltans, developmental dysplasia, or other hip pathologies. MRI can be helpful to diagnose thickened iliotibial band or thickened anterior edge of the gluteus maximus muscle. Additionally, a positive response to anesthetic joint injection in the affected area can help distinguish between external and internal snapping hip syndrome [3–9].

21.1 Treatment

The majority of patients find relief with changes in activity, rest, ice, and stretching. If symptoms are not relieved and pain is still present upon snapping, treatment is still conservative and consists of steroid injections, oral anti-inflammatory medications, and physical therapy. If pain persists despite these conservative measures, surgical intervention can be considered.

The principle of the surgery is to decrease tension and create loosening of the iliotibial band. Different surgical techniques have been described as follows:

- Lengthening the IT band by doing a Z-plasty [2, 10].
- Creating a defect over the GT: resection of a posterior portion of the ITB [11], elliptical resection [12], or step-cut procedure [3]. Ilizaliturri et al. [13] have described an endoscopic release with a vertical cut and a transverse cut at the middle of the vertical release creating a cross shape, made using an RF hook probe. Next, the four resulting flaps are resected to make a diamond-shaped defect (Figs. 21.1, 21.2 and 21.3).

Fig. 21.1 In the space between the ITB and GT, tenotomy of the femoral insertion of the GMT

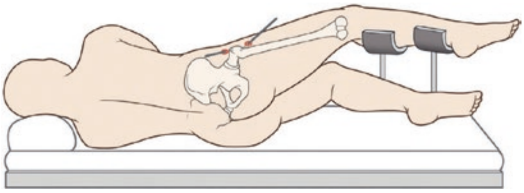

Fig. 21.2 Lateral position, the right hip is operated on. Portals are placed one at the superior tip of the GT and the other approximately 10 cm below the tip of the GT, in line with the axis of the femur

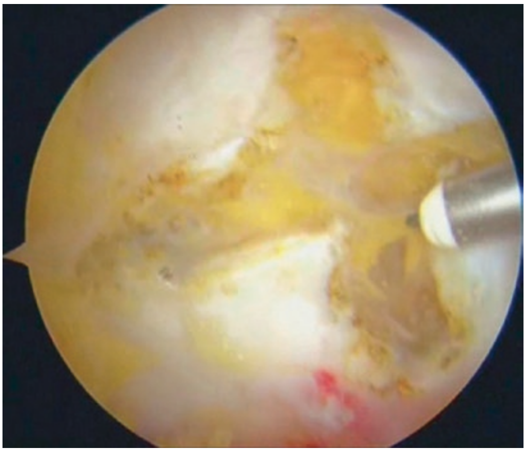

Fig. 21.3 Arthroscopic view of a cross shape release of the IT band

– Releasing the femoral insertion of the gluteus maximus tendon (Polesello technique) using a radio frequency device close to the linea aspera [14]. The iliotibial band is tensioned anteriorly by the tensor fascia lata and posteriorly by the gluteus maximus, both working synergistically in normal conditions. Therefore, the iliotibial band, gluteus maximus, and tensor fascia lata work as a single complex. As the iliotibial band is closely related to the gluteus maximus tendon, by relaxing the GMT, the ITB may relax as well [15].

Weakness in abduction may be a complication if the release is excessive or there is damage to the surrounding area. Corrective surgeries can result in other complications including infection, heterotopic ossification, muscle atrophy, continued symptoms, or nerve damage.

21.2 Conclusion

Snapping hip or coxa saltans is a frequent syndrome that occurs especially with sport activities. Diagnosis is done by physical examination. Imaging can be useful to rule out other hip pathology and search local complication or anatomical situations may predispose. The treatment depends on the presence of symptoms; asymptomatic patients require no treatment. Those with pain should be encouraged to rest and enroll in a physical therapy program but the majority of patients find relief with changes in activity, rest, ice, and stretching. Surgery is the last resort treatment and should only be considered once conservative treatment has failed [6]. The principle is to decrease the tension of the iliotibial band by lengthening, creating a defect or releasing the femoral insertion of the gluteus maximus tendon. All techniques can be performed both open and arthroscopically.

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22 Gluteus Medius Repair – Endoscopic

Carlomagno Cardenas Nylander

22.1 Introduction

Greater trochanter pain syndrome (GTPS) is one of the most frequent reasons for seeking orthopedic advice community-based studies show prevalence as high as 15% [1]. Conservative therapy was traditionally the common initial approach and still a valid strategy within this group [2]. Before the development of modern MRI and ultrasound investigation, many patients were labeled as trochanteritis or trochanteric bursitis, a diagnosis rather vague and generic. Gluteus medius tears, a previously not well recognized by orthopedic surgeons [3] it is now a widely accepted entity responsible for a large number of cases of GTPS [4].

22.2 Epidemiology and Presentation

Most of the patients affected are middle age women [5], factors as skeletal morphology, and the mechanical consequences of a wider pelvis has been associated with tears as well as obesity and lower lumbar spine pathology [6]. Lateral pain is the main symptom, frequent at nights when lying down on a bed or early in the morning; activities like long walks, stairs, and slopes upwards make the symptoms worsen. Trochanteric hypersensibility it's almost always a finding [7], most of the patients have pain in lateral decubitus, either because hyper pressure coming from patients own weight, or iliotibial band (ITB) friction over the GT when laying down on the opposite side due to adduction of the knee. Limping can be part of the presentation, mild limping due to pain is frequent, but a long history of limping and the use of a cane or crutches suggest advanced disease and severe damage to abductor apparatus.

There are different scenarios for gluteal tears presentation and cause:

1. Degenerative chronic tears: This is the most common situation, the patient has a variable history of intermittent pain and age-related contributing factors, such as poor tissue quality, fatty atrophy, diminished vascularity, and microcrystal deposition disease.
2. Iatrogenic tears: Secondary to lateral—transtendinous hip approaches.
3. Traumatic tears: An uncommon presentation, limited cases described in the literature. Some are acute ruptures over a chronically affected tendon.

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22.3 Patient Selection for Surgery

Most of the patients respond positively to conservative measures, exercises, physical therapy, injections based on corticoids [8]—biologics and modifications of lifestyle, but since most of the cases are chronic degenerative tears, relapse it is not uncommon after some months or years.

MRI its routinely used to evaluate the extent of the tear; modern ultrasound evaluation has many advantages over MRI: dynamic assessment, convenience, price, and availability, but experienced musculoskeletal radiologist is necessary.

In patients with tendinitis or very small tears (Fig. 22.1), conservative measures should be tried first. If it fails of symptoms came back soon, surgeons must rule out other causes of lateral pain like hip dysplasia or intra-articular pathology; two-thirds of dysplastic hips have lateral pain [9].

In patients with small- and medium-size tears and mild retraction (Figs. 22.2 and 22.3), conservative measures should be tried. The need of later surgical intervention is higher than in the tendinitis group; the patient must be aware of this from the beginning, this group is the ideal for open or endoscopic repair since the muscular unit still functional and reattachment is easy to achieve.

Very large tears with retraction and fatty degeneration are challenging (Fig. 22.4), surgical procedures have added complexity, and results are not as predictable as small tears. Some of these patients may need an augmentation procedure with an allogenic patch, tendon, or synthetic graft; others may be better addressed with open procedures like muscle transfer procedures, e.g., Whiteside plasty (Fig. 22.5).

Fig. 22.1 MRI: Edema and signal change around gluteus medius and minimus tendon

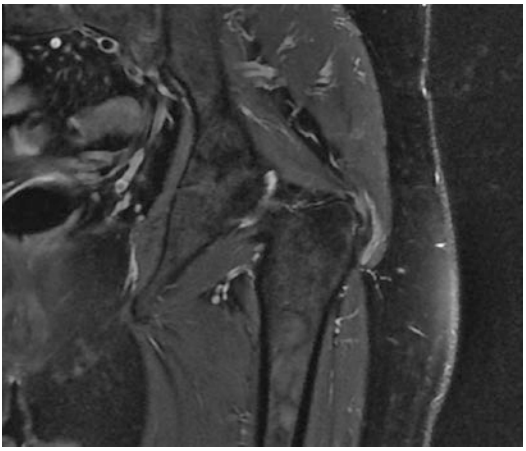

Fig. 22.2 MRI: Coronal image of the left hip, edema, and mild tendon retraction

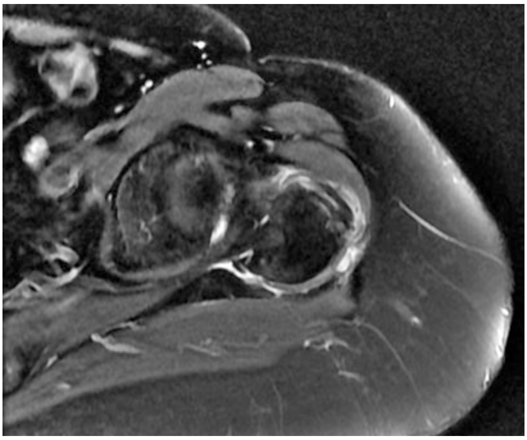

Fig. 22.3 MRI: Axial image of the left hip, peritrochanteric edema, and tendon fragmentation

Fig. 22.4 MRI: Right hip with tendon retraction and fatty degeneration

22.4 Open Versus Endoscopic Treatment

Tendon reattachment can be accomplished with both modalities. Surgeons coming from a sports medicine environment will find endoscopic more convenient for the patient, avoiding a large incision and open dissection. Recon surgeons used to open procedures like total hip replacement will feel comfortable with a mini-open lateral approach, a straightforward procedure, short in time and learning curve (Video 22.1).

There is no doubt that endoscopic skills play an essential role in how those tears can be treated

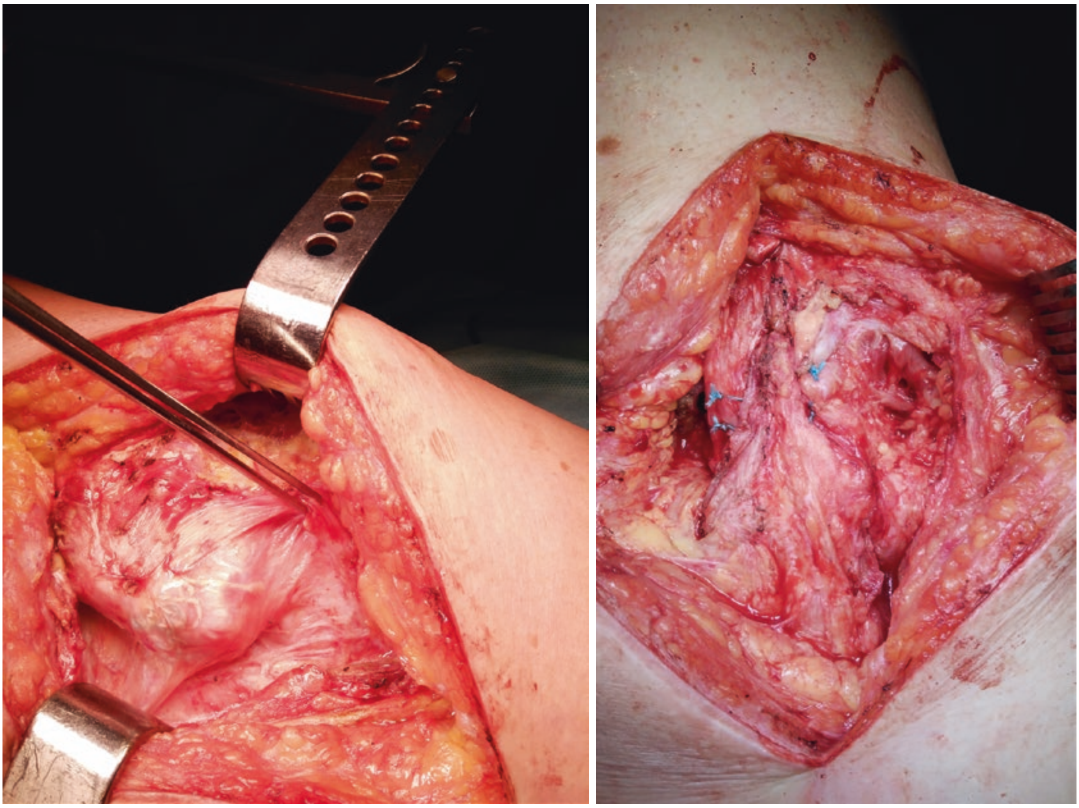

Fig. 22.5 Whiteside plasty on a failed gluteus medius repair after THA, on the left image a "bald" trochanter with no muscular attachments, on the right side gluteus maximus transfer to GT

successfully. In the author's perspective, most tears can be treated by endoscopic means, but the time required to complete the procedure still favoring open over endoscopic. In general, at the time this chapter is written a minority of surgeons in the hip field performs endoscopic repairs routinely rather than open that proportion should be inverted as new tools and techniques are developed in the upcoming years.

- *Tip: Novell surgeons should try small partial tears before large tears with tendon retraction and/or tissue defects, trochanteric bursectomy it's a good starting procedure in the learning curve of peritrochanteric space endoscopy.*

22.5 Patient Positioning

The patient may be positioned supine or lateral on hip arthroscopy distractor attachment, a minority of surgeons use lateral decubitus on a distractor, and some others use the lateral position without any traction device. Preferences on patient position are based mostly on training, the approach used, and technical resources. A dominant number of surgeons use the supine position on a traction table or attachment. In any case, the leg should be free to rotate internally and externally as well as move laterally in abduction (Fig. 22.6) to release the tension on the iliotibial band and improve subfascial space.

Fig. 22.6 Affected extremity should be able to move in abduction

22.6 Portals and Access to Peritrochanteric Space

The most common way used to approach the lateral compartment of the hip is by conventional portals to the peritrochanteric space, the procedure aims to portal placement below the iliotibial band (ITB) in an **all-in** fashion without incising the fascia. Another popular approach is the subcutaneous approach, where dissection of the subcutaneous tissue over the ITB is carried out before opening the fascial structure longitudinally over the GT.

Technical note for conventional portal (all-in) approach:

1. *Begin with leg abducted at 20–30° to ease ITB tension and slight internal rotation to compensate for femoral version and lateralize the GT as much as possible.*
2. *Place a slightly distal AL portal at the level of the lateral ridge (limit between gluteus medius insertion and vastus lateralis insertion) incise the skin and introduce a bridge sheath with trocar at 45–50° of inclination over the ridge and then vertically next to bone reaching the space between GT and ITB (Fig. 22.7), move sheath proximally and distally on the frontal plane to create space (Video 22.2), remove the trocar and check air presence on the c-arm (Fig. 22.8) we named it as the "cloud sign", that confirms successful peritrochanteric portal placement.*
3. *Turn the pump on (start with low pressures <40 mmHg) explore space with 70° scope and add a distal trochanteric portal (DTP), proximal trochanteric portal (PTP), and direct trochanteric (DT) or posterior portal (PP) as needed, you may use as many as necessary (Fig. 22.9) to handle the procedure efficiently, cannulas and especially portal savers might be useful. Use the light from the scope tip to find desire location of portals (Fig. 22.10). Make sure the location of portals fits the area around the tendon insertion at the GT facets, this is critical to achieving comfort during the procedure.*
4. *Perform a bursectomy and move your scope to DTP, expose lateral trochanteric area, you should be able to identify Gmax tendon inser-*

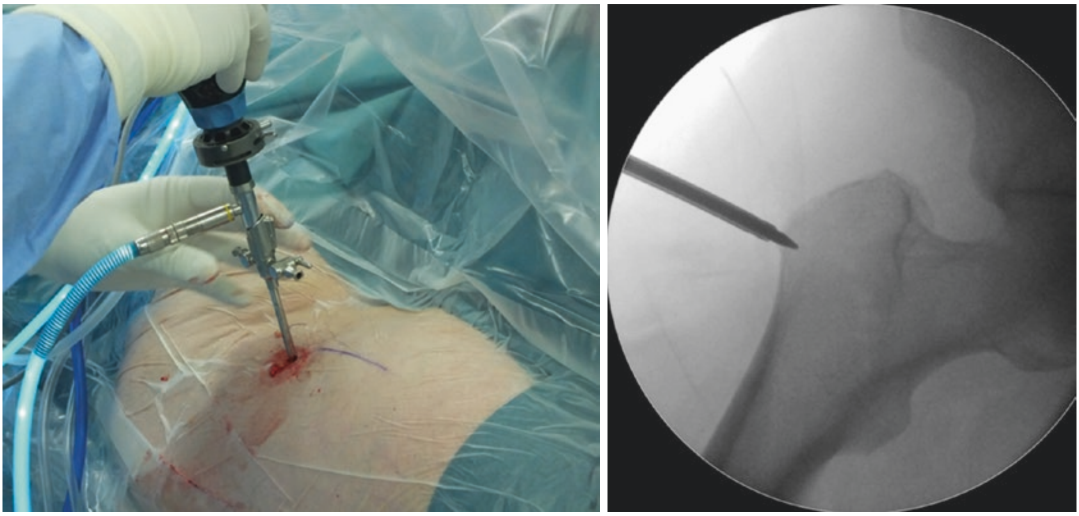

Fig. 22.7 Modified AL portal, C-arm image shows the trochanteric ridge and scope sheath

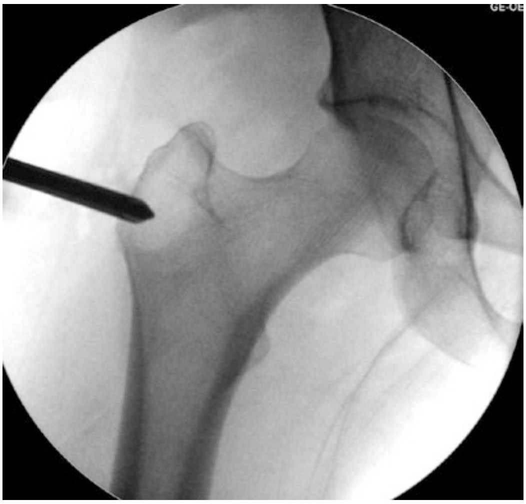

Fig. 22.8 “Cloud Sing” air in the posterolateral compartment, confirms portal placement on the peritrochanteric space

tion (Fig. 22.11), GT, gluteus medius tendon, vastus lateralis, and ITB (Video 22.3). Dissection is carried out better with RF rather than shaver blade; a bleeding event is more likely with mechanical tools.

Technical note for subcutaneous approach:

1. *Position the leg in extension and slight internal rotation, use C-arm and needles/switching*

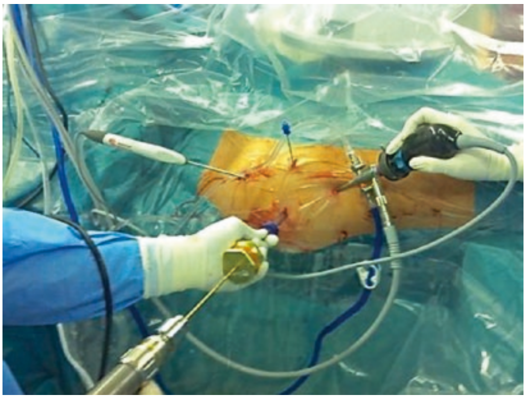

Fig. 22.9 Multiple portals around the trochanteric area

Fig. 22.10 Use scope light to select new portals location, useful for the direct trochanteric portal

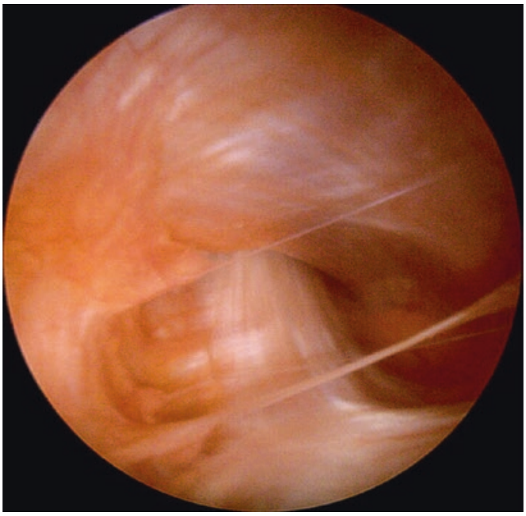

Fig. 22.11 Guteus maximus tendon insertion under vastus lateralis

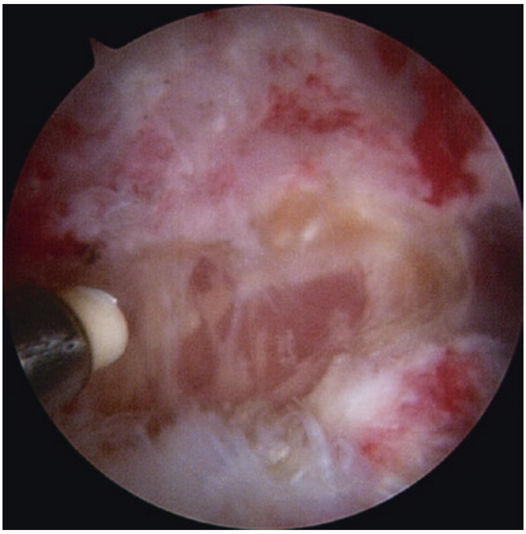

Fig. 22.12 Longitudinal incision of ITB using RF

stick to mark portal direction towards GT, Incise the skin proximal and distal to GT according to desired entry points DTP and PTP.

2. *Insert bridge sheath with trocar in PTP until resistant from fascia is reached, put the 30° scope in and let a switching stick from the DTP find it in the fatty tissue at the level of intertrochanteric ridge, then replace the switching stick with the RF probe, dissect the subcutaneous tissue over the ITB exposing the area distally and proximally, perform hemostasis of perforating vessels as required*
3. *Open de ITB longitudinally over the long axis of the femur (Fig. 22.12), abduct the leg 20–30° to ease ITB tension and perform bursectomy to expose lateral peritrochanteric area.*
4. *Ad portals as needed to carry out the procedure.*

22.7 Partial-Thickness and Small Full-Thickness Gluteus Medius Tears

- *Tip: These tears might not be apparent, because the tear lies on the deep surface of the tendon, in some cases, a bruising area can be noticed on the outer surface; thinning and detachment can be palpated with an arthroscopic probe, alternate rotation ER/IR may help to find affected zone (Video 22.4).*

Technical note: author's preferred method

1. (a) *Incise the tendon longitudinally starting distally over the lateral facet opening in line with fibers proximally and anteriorly (Video 22.5).*

   (b) *For small tendon flaps: debride tendon flap margins and resect excess of bursae with a less aggressive shaver blade, a clear tendon should be left for repair (Video 22.6).*
2. *Debride inner pathologic tendon layer.*
3. *Resect any enthesophyte or bone spur of the lateral facet creating a bleeding bed for tendon reattachment (Video 22.7).*
4. (a) *Insert anchors on the naked footprint (Fig. 22.13) and use your preferred device to pass sutures through the tendon and approximate back to the trochanteric facet tying the knots. Side to side for transtendinous technique and single row for small flaps are the most used configurations for tendon fixation.*

   (b) *An alternative method using knotless anchors may be used, passing the suture either side to side or in a half mattress stitch and then placing the anchor adjusting the tension before firing the locking mechanism (Fig. 22.14).*

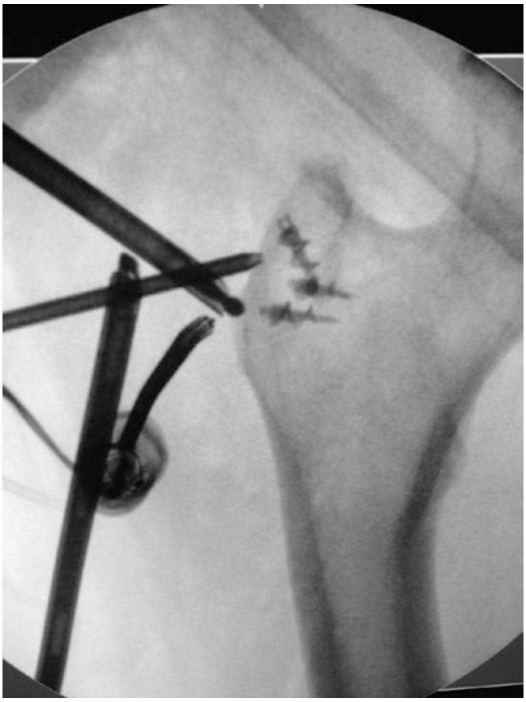

Fig. 22.13 Metal anchors placed in the lateral and anterior facet

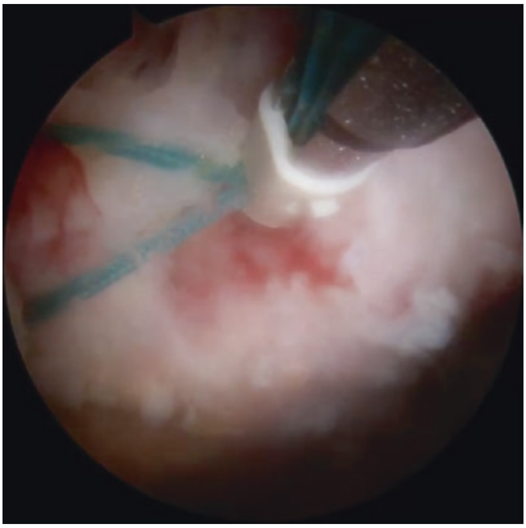

Fig. 22.14 Knotless anchor for gluteus medius repair

Tip: Tendon tension may be adjusted with the rotation of the leg: internally rotating the leg, grabbing enough tissue from the flap and inserting anchors latero-posterior as possible on the footprint, allows reattaching the tendon flap in maximum tension. Do no overtight tendon and check tension at the end of the procedure.

Tip: Anchor placement may affect bone properties, large anchors, multiple anchors, or pilot holes cause a potential area for late fractures, especially in bad bone quality patients. When multiple anchors are necessary, all suture, small diameter anchors may have a better security profile than hard conventional.

5. *Check tendon tension, rotating the leg externally and releasing it, a rebound rotational movement towards to internal should occurs, this confirms a well-tensioned tendon (Video 22.8).*

Whatever technique used, tendon repair must be as anatomical as possible, achieving appropriate tension and resistant to a stress test in external rotation.

22.8 Gluteus Medius Augmentation Procedure

If tendon continuity is compromised or tendon thickness is significantly diminished an augmentation procedure may be necessary.

Different graft options for tendon augmentation have been tried, synthetic, human dermal acellular matrix or biologic from bovine origin.

Technical note

- *Once the need to reinforce tendon its clear, measure the area to be covered with a probe and adjust the graft (Fig. 22.15) size with scissors, place a minimum of two proximal transtendinous small diameter anchors on the GT, retrieve the sutures on the PTP and pass it through the proximal part of the graft one at each corner and push the graft into the lateral space through a cannula (keep in mind the desired side of the graft to be in contact to patient's tendon). Once the proximal part is secured, place additional anchors distally on the GT according to the previously measured with the probe and fine adjust anchor position in line with the graft tension,*

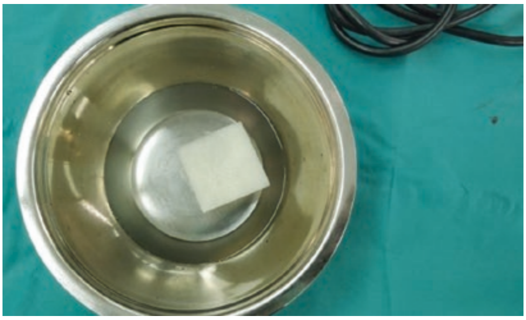

Fig. 22.15 Human acellular dermis prior to trimming to fit defect

once distal anchors are placed bring the sutures through the graft and secure distally. A four-corner fixation is secured as described by Laskovski [10]*, additional fixation on the perimeter its placed as needed.*

- *Tip: Endoscopic augmentation is a technically demanding procedure. In cases, with a significant defect over the bony GT an open procedure should be considered to guarantee graft fixation not only over the defect but also a solid triple fixation bone-tendon-graft at multiple points over the GT.*

22.9 Post-op and Recovery

Weight-bearing protection with two crutches is advised for 6 to 8 weeks, followed by one crutch transition for 2–4 additional weeks according to defect, type of procedure, and patient's tolerance. An abduction brace can be used to protect the repair. Skin sutures are removed after 2 weeks, and progressive physical therapy starts with muscular isometric exercises and limited ROM avoiding combined flexion-external rotation. Ultrasound assessment is done every month for the first 3 months to check tendon continuity and monitor seroma reabsorption if necessary.

22.10 Complications

Gluteus medius repair seems to be a safe procedure with a low rate of adverse post-op events. Procedure specific complications still possible under certain conditions

Fig. 22.16 Large bruising after subcutaneous approach to peritrochanteric space

- Bleeding: perforating vessels are generously distributed along ITB, subcutaneous dissection, and ITB longitudinal incision should be carried out along with careful hemostasis. Peritrochanteric fatty bursa is also well irrigated, and so RF dissection is recommended instead of shaver bursectomy. Failure to achieve adequate hemostasis may lead to subcutaneous extensive bruising and hematoma (Fig. 22.16).
- Liquid extravasation (specific to endoscopic procedures): As a general rule in hip arthroscopy keep pressure as low as possible to obtain adequate visualization, high pressure for long periods may lead to liquid extravasation and subcutaneous or compartment edema (Fig. 22.17)
- *Tip: Perform hemostasis during dissection and lower pump pressure to 30 mmHg at the end of the procedure to check low-pressure bleeders and coagulate them.*
- Graft and suture failure: Inadequate graft, tendon fixation or post-op protocol violation may cause repair-graft tissue to fail.
- Fracture: Multiple hard anchors and large diameter anchors in patients with inadequate bone quality create weak areas and potential trochanteric fractures (Fig. 22.18).

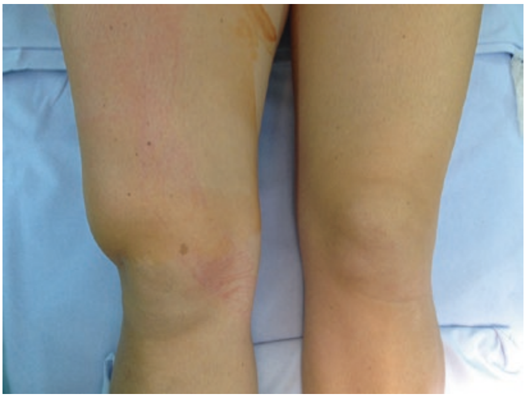

Fig. 22.17 Liquid extravasation secondary to gluteus medius repair

Fig. 22.18 Trochanteric fracture secondary to mild trauma. Recent gluteus medius repair (1 month)

22.11 Final Thoughts

Surgical repair of gluteus medius tears is a valid option to restore the abductor anatomy in symptomatic patients with tears who failed conservative therapy. Current surgical approaches include open and endoscopic, and surgeons may select an approach according to training and preferences. This is a large group of patients with multiple treatment options, ranging from modification of activities–exercises–education to complex muscle transfers and augmentation procedures; tailored treatment for each case is key to success.

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Gluteus Medius and Minimus Tears Open Repair/Reconstruction

23

Panayiotis Christofilopoulos,
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23.1 Introduction

The pathology of abductors' tendons is the most common cause of lateral thigh pain or greater trochanteric pain syndrome (GTPS) both in native and in prosthetic hips [1]. The spectrum of GTPS pathology ranges from tendinosis to complete tendon rupture, retraction and fatty atrophy of the gluteal muscles. The popularization of imaging facilities and the greater awareness of physicians subsequently led to a higher reported incidence rate of the syndrome [2]. GTPS is more prevalent in women than in men with a peak prevalence found between the fourth and sixth decade of life [3]. It is often misdiagnosed with trochanteric bursitis; however, no ultrasound detected bursitis could be confirmed in 80% of patients suffering from GTPS. On the other hand, trochanteric bursitis is usually combined with abductor tendon or fascia lata pathology; only 8% of patients suffer from bursitis in the absence of other pathology [1].

23.2 Anatomy of Gluteal Muscles

23.2.1 Gluteal Muscle Origin

The gluteus medius (GMed) originates from the anterior superior iliac spine and the outer edge of the iliac crest back to the posterior superior iliac spine. The GMed is composed of three separate parts the anterior, the middle and the posterior, all innervated by the superior gluteal nerve [4]. The muscle fibres of the anterior and middle portions of the GMed are vertically oriented and have a critical role in initiating the hip abduction [5]. The gluteus minimus (GMin) initiates from the anterior–inferior iliac spine back to the posterior inferior iliac spine between the inferior and anterior gluteal lines. Both the GMin and the posterior portion of GMed are horizontally oriented and parallel to the femoral neck, stabilizing the hip joint in different phases of the gait cycle [5].

23.2.2 Gluteal Muscles Insertion

Recent cadaveric studies further sorted out the complex anatomy of gluteal muscles [6] highlighting the two different attachment sites of the GMed into the greater trochanter (Fig. 23.1). The posterior and part of the middle portion of GMed are inserted separately on the posterosuperior facet of the greater trochanter; this facet

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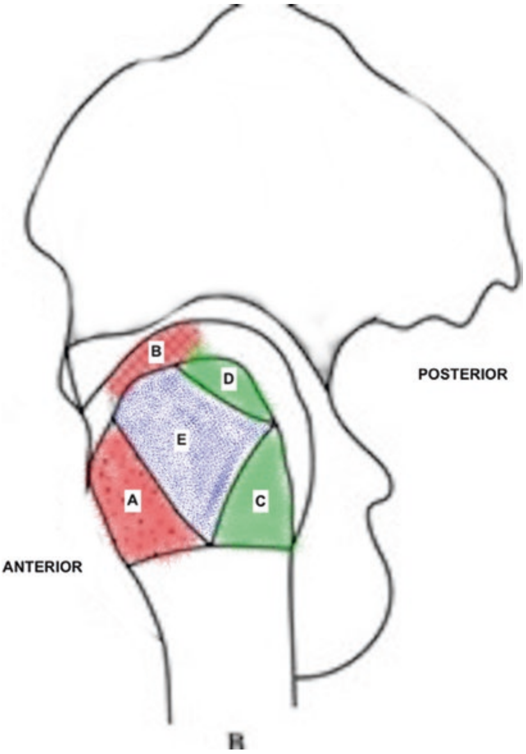

Fig. 23.1 Insertion sites of the Gluteus Medius and Minimus into the greater trochanter; *A*: trochanteric attachment of GMin, *B*: Capsular attachment of GMin, *C*: Posterosuperior facet of GMed, *D*: Lateral Facet of GMed, *E*: "bold area"

has a roughly circular shape with a radius of 8.5 mm. The rest of the middle and the anterior part of GMed are inserted on the lateral trochanteric facet, which is almost trapezoidal and has a greater surface area. In a cadaveric study of eight femora, the insertional footprint of the lateral facet of GMed demonstrated a mean length of 35 mm and an angle of 37° to the axis of the femur. It was wider proximally and narrower distally, the width being around 12 mm at the midpoint [6]. GMin has fascicular attachments to the anterior hip capsule but also inserts to the anterior and lateral facets of the greater trochanter. An area bare of tendon attachments separates the insertional facets of GMed and GMin; this so-called bald spot serves as an anatomic landmark, particularly in the endoscopic approach to the hip [6].

23.3 Epidemiology and Aetiopathogenesis of Gluteal Tendon Pathology

23.3.1 Epidemiology

Almost half of the patients suffering from GTPS demonstrate gluteal tendinosis or ruptures. The rate of gluteal tendinosis and ruptures increases with age. The incidence of gluteal ruptures raises from 10% lower than 60 years to 50% over 70 years of age [7].

23.3.2 Aetiopathogenesis

The aetiopathogenesis of abductor insufficiency is mainly attributed to the altered lower limb biomechanics, especially in the setting of hip osteoarthritis. Ruptures of gluteal tendons have been reported up to 20% of patients suffering from hip OA and 25% of patients undergoing total hip arthroplasty (THA) for end-stage hip osteoarthritis [8, 9].

23.3.3 Clinical Scenarios

Three distinct clinical scenarios have been described for the tears of the hip abductor muscles. The so-called rotator cuff of the hip [10] may suffer from atraumatic chronic tears of the anterior part of GMed, tears found unexpectedly during hip arthroplasty surgery for femoral neck or osteoarthritis and avulsion tears of abductor tendons resulting from hip arthroplasty through a transgluteal approach [4]. Iatrogenic damage to the abductors' tendons following a transgluteal hip approach is often reported due to deficient healing of the disruption site [11]. However, abductor insufficiency is also met in abductor sparing approaches, highlighting also the role of altered hip mechanics in the tear pathogenesis. Both abductor fatigue and inflammatory process seen in THA patients including excessive wear and osteolysis and especially metallosis can lead to excessive abductor tendon damage, rendering direct repair impossible and possibly necessitating more complex reconstructive options [12].

23.4 Clinical Presentation

The chief complaint of abductor tendon pathology is lateral thigh pain that is usually aggravated by lying on the affected limb, walking or climbing stairs [4].Tenderness over the site of abductor insertion and the superior and lateral facets of the greater trochanter is also a typical clinical finding. Anterior groin pain is also described; however, it is less common, and when reported other potential sources of pain should be ruled out [13]. The pain worsened over the fascia lata may also suggest abductor tendon pathology.

23.5 Clinical Examination

The patient often demonstrates a slight or moderate limping. A positive Trendelenburg sign often indicates abductor tendon tears; it is defined as a truncal sway to the contralateral side on stance phase on the affected limb. The sensitivity and specificity of the Trendelenburg sign for abductor tear are reported to be 73% and 76%, respectively [14].

23.5.1 Specific Tests

The hip lag sign is another useful test in diagnosing abductor insufficiency with a reported sensitivity of 89% and specificity of 96%. It is performed with the patient in the lateral position with the affected side up. The clinician passively extends the hip 10°, abducts 20°, and then maximally internally rotates the hip with the knee in 45° of flexion. The leg is then released, and the patient is asked to hold it in the upright position; if the leg drops more than 10 cm, the test is considered positive [15]. Additional useful tests are the 30-s single leg stance and the external derotation tests. In the former, the patient is asked to perform a 30-s single leg stance and no trunk deviation; the arrival of lateral thigh pain is considered a positive result [16]. The passive hip range of motion is not limited, but the force of hip abduction may be weakened. Besides, a thorough clinical examination should be performed including the evaluation of muscle strength, neurologic status, lumbar spine, and hip or fascia lata pathology; in patients that underwent THA, the integrity of the prosthetic joint must also be checked.

23.6 Imaging Studies

23.6.1 Magnetic Resonance Imaging (MRI)

MRI is the gold-standard examination of the anatomy and pathology of the abductor muscles and tendons [3]. The reported sensitivity and specificity of MRI to predict GMed tendon tears is 73% and 95%, respectively [17]. Advanced MRI protocols, as the metal artefact reduction sequences (MARS) and multiple acquisitions with variable-resonance image combinations MRI (MAVRIC), facilitates the study of abductors in the setting of prosthetic hips. Information regarding the size and shape of gluteal muscles and tendons, tendinosis, partial or complete tendon defects or fatty infiltration of the muscles can be obtained. Several MRI findings have been related to tears of abductors' tendons as a high sign superior or lateral to the greater trochanter, GMed tendon elongation or discontinuity [17]. TFL hypertrophy is also an indirect sign of abductor tendon tears [18].

23.6.2 Evaluation of Fatty Infiltration Using MRI

The Goutallier-Fuchs classification rates the degree of fatty infiltration of abductors on MRI, that ranges from 0 to 4 grades. Grade 1 is related to some fatty streaks of the muscle, grade 2 has fatty infiltration but more muscle than fat, grade 3 fatty infiltration with equal fat and muscle and grade 4 more fat than muscle on MRI [19]. It is supported that the extent of abductor muscle fatty infiltration is predictive of repair outcomes, with a high grade (>2) being linked to inferior results

[19]. Bogunovic et al. demonstrated that the greater the fatty infiltration of the muscle, the higher the postoperative pain level and lower the functional outcomes of the patients, highlighting the prognostic role of this classification [19].

23.6.3 Standard Radiographs

Standard hip and pelvic radiographs should be performed. Greater trochanter enthesophytes or surface irregularity greater than 2 mm have been associated with abductor tendon pathology, especially in the chronic setting (Fig. 23.2). Steinert et al. showed that 90% of the hips having greater trochanteric irregularities larger than 2 mm also demonstrated GMed or GMin tendon abnormalities [20]. In patients with prosthetic hips, the radiologic evaluation is more than necessary to rule out concomitant THA pathology. Additional views such as Dunn or false profile views are performed as needed; the presence and extent of osteolysis, especially around the greater trochanter, should be carefully evaluated.

23.6.4 Ultrasound

Ultrasound may be beneficial, especially in the setting of THA or the absence of advanced MRI protocols for artefact reduction. It can accurately diagnose tendinopathy and tears; however, it is user-dependent, and inferior to MRI in classifying the degree of fatty atrophy.

Fig. 23.2 Standard anteroposterior pelvic radiographs demonstrating greater trochanter enthesophytes greater than 2 mm

23.7 Treatment

(a) *Conservative*

The treatment of GTPS syndrome usually starts conservatively including short-term use of nonsteroidal anti-inflammatory medication, activity modification, physical therapy and prudent use of corticosteroid plus local anaesthetic injection into the tender trochanteric bursa. If conservative management fails to relieve the symptoms following at least 3 months of therapy, surgical treatment usually follows [21].

(b) *Surgical*

Surgical management is mainly indicated for full or partial gluteal tendon ruptures that are nonresponsive to conservative treatment, eliciting pain and disability to the patient. The main goals of the surgical treatment of gluteal tears are the preservation of the function and quality of life of the patients and the reduction of pain.

23.8 Preoperative Evaluation

The patients that are scheduled to undergo surgical repair of gluteal tendon tears must undergo a thorough preoperative evaluation, including clinical and radiological evaluation. Special care is needed preoperatively concerning the following:

(a) *Neurologic Evaluation*

A neurologically intact abductor muscle is a prerequisite for any attempt to directly repair an abductor tear. A detailed screening for lumbar spine pathology or other types of neurologic impairment of gluteal muscles must be routinely performed preoperatively. In cases of neurologically impaired gluteal muscle, the direct repair of a tear predominantly fails and other reconstruction techniques as synthetic grafts or muscle transfers may be required.

(b) *Fatty Infiltration of Gluteal Muscles*

It has been recognized that extensive fatty infiltration of abductors muscles is a predictive factor of inferior repair outcomes. A Goutallier classification grade >2 is highly predictive of more inferior results [19]; in such cases, other more complex reconstruction techniques as muscle flaps or grafts may be needed.

(c) *Presence of THA*

In the setting of an existing THA, the joint should be thoroughly evaluated preoperatively to exclude aseptic loosening or any other pathology that could potentially necessitate a concurrent revision of the prosthesis. Special care should be given to the radiologic appearance of the greater trochanter, as excessive osteolysis can render fixation of the tendon on cancellous bone risky or even insufficient. In cases of a previous infected THA or excessive wear following a failed metal on metal THA, the quality of tendon is often unreliable and augmented repair or transfer of local muscles may be needed.

(d) *Fascia Lata or Iliotibial Band Tightness*

Preoperative and intraoperative evaluation of the tightness of iliotibial band or fascia lata should be performed, and appropriate corrections should be made concurrently with the abductor repair. One of the main advantages of the open approaches is the easy and precise lengthening of iliotibial band or fascia lata that can be performed when needed with a V-Y technique.

23.9 Surgical Techniques

The standard patient positioning is the lateral decubitus with the involved extremity on the top. Standard sterile prepping and draping is performed keeping in mind to drape from the iliac crest to the knee, especially in the setting of reconstructive surgery. A Mayo table or similar device is necessary to facilitate the leg abduction during the tensioning of the repair.

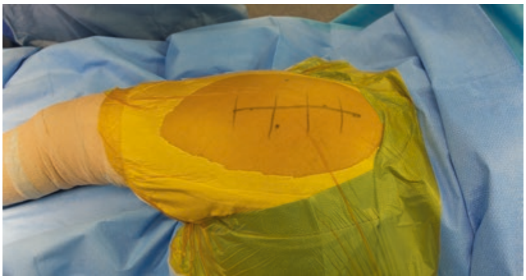

Fig. 23.3 A standard straight incision centred over the greater trochanter along the femoral axis usually performed for direct open repair of hip abductor tendons

A straight incision centred over the greater trochanter along the femoral axis extending proximally and distally as needed is usually performed (Fig. 23.3). A 10–15 cm incision length enables adequate visualization of the involved anatomic structures in the majority of patients. In case of simultaneous revision THA or more complex abductor tendon reconstructions, the incision should be modified accordingly.

Various types of open procedures for the management of abductor tears have been reported; the following three categories of direct open methods are further discussed.

(a) Nonaugmented direct repair
(b) Augmented direct repair
(c) Reconstruction techniques

23.10 Direct Open Nonaugmented Repair Using Bone Tunnels or Suture Anchors

A prerequisite for direct open repair of abductor's tendon is the neurologic integrity of the muscle and fatty infiltration level Goutallier <2. The patient is positioned usually in lateral position. Following a standard incision of skin and division of the fascia lata, the trochanteric bursa and glutei attachment are exposed. Once bursectomy is performed, the surgeon can evaluate the quality, type and extent of the rupture of the gluteal tendon (Fig. 23.4a, b). Sometimes the rupture is not evident at first sight. Injection of saline under the insertion of gluteal tendons can cause

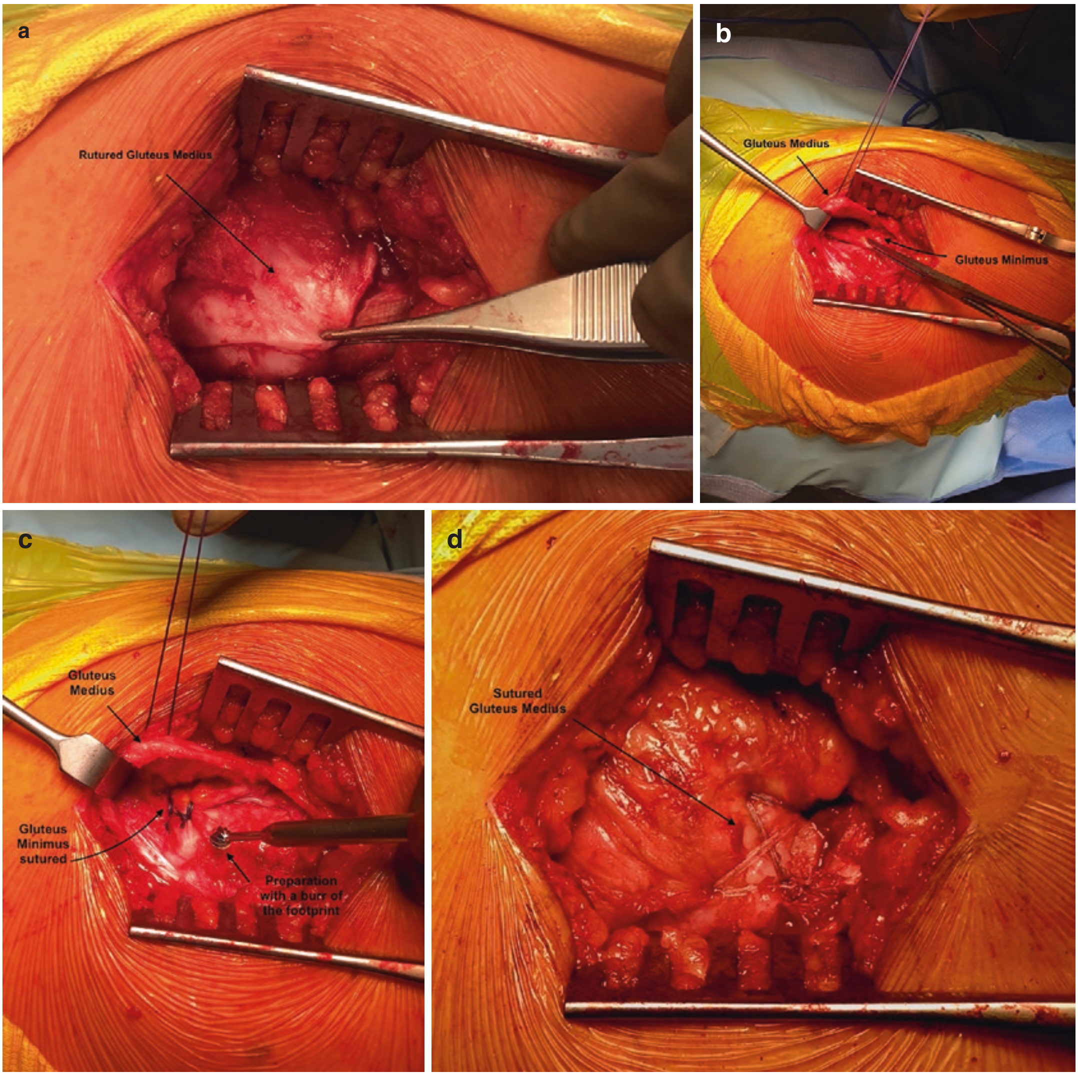

Fig. 23.4 Direct open nonaugmented abductor tendon repair. (**a**) Gluteus medius tendon rupture, (**b**) gluteus minimus tendon rupture, (**c**) preparation of the footprint for tendon attachment, (**d**) final result of both tendon attachment with anchors

elevation of the tendinous insertion; this is the so-called bubble sign indicating an undersurface rupture. In cases of doubtful tendon tears, one may split GMed fibres in line to gain access to the undersurface of the tendon and evaluate the extent of rupture. Before splitting the muscle, sutures must be placed on the opposite tendon sides to help with the anatomic repair. In cases of severe tendinosis, an aggressive debridement should be avoided to preserve the maximal tendon length and width, preventing also tensioning or nonanatomic repair [22]. Once the tendon tears have been recognized, the bone bed area should be prepared with a burr or nibbler, making sure not to remove excessive bone, particularly in the setting of an existing THA with osteolysis. Microfractures can be performed; however, caution should be taken not to over weaken bone adjacent to anchor holes.

If possible, four pairs of bone tunnels should be drilled on the lateral facet for full ruptures of the GMed. In partial ruptures, the number of tunnels can be modified accordingly; however, a minimum of two tunnels is required to ensure adequate contact of the tendon to the repair site. In cases of GMin tears, an additional pair of tunnels should be drilled on the anterior tubercle of the greater trochanter [23]. The bone tunnels for GMed reattachment should be performed perpendicularly to the long axis of the footprint, parallel to the long axis of the femur, whereas tunnel(s) for GMin reattachment should be done in an oblique plane. Thick nonabsorbable pull sutures should be used in a Bunnel, Krakow or similar locking type technique, passing through the tendon ends and bone tunnels and tied down under maximum tension to reapproximate the tendons to their footprint. Additional thin sutures are usually needed, passing through the tendon to enhance the repair.

In the case of a native hip, aiming not to disturb the vascular supply of the femoral head, suture anchors can be used instead of bone tunnels. Two to three proximal anchors are usually placed in a proximal row and other two distally to serve for the double row effect. The size of the anchors should be adjusted depending on the bone area and the presence of a femoral stem [24]. Anchors of 5–6.5 mm diameter are often preferred to overcome the pulling stress due to the underlying cancellous bone of the greater trochanter. Following bone preparation of the abductors' footprint, the proximal anchor holes are drilled and anchors placed (Fig. 23.4c, d). The sutures were then passed through the GM flap and tightened, transferring the flap on the major trochanter with the hip in abduction of 15–20°. Suture placement should account for final tendon positioning and row width, usually 5–10 mm from the tendon edge. After tendon approximation and proximal row suturing, the distal-row anchors are placed and the new sutures increase tendon compression on the bone. A similar approach is used for GMin tears; however, due to the smaller insertion site and capsular attachments of the muscle, one or two anchors can be maximally used [25].

The appropriate tensioning of the repair is checked with the leg in abduction of about 20–30°. When needed, a blunt release of the glutei is performed taking care to avoid the superior gluteal nerve. Besides, the fascia lata can be elongated via a V-Y technique.

Postoperatively, the patient is educated to walk with nonweight or partial weight bearing for 6 weeks with two scratches avoiding active hip abduction; then, hip abductor strengthening and active physiotherapy can be commenced [22–25].

The direct open nonaugmented repair with sutures passing from bony tunnels is a straightforward technique; however, the inadequate mechanics and substantial delay of the repair ends to a high reported failure rate up to 25% [26]. In a retrospective study, 18 patients underwent open repair of abductor tears following THA with lateral approach, using sutures passing through bone tunnels; only half of them have substantial improvement of both limp and pain at 38-month follow-up [24]. A high failure rate was also reported in other studies where suture anchors were used to managing chronic abductor tears. Davies et al. reported five failures of 16 patients that underwent surgical repair using multiple soft tissue anchors inserted into the greater trochanter of the hip to reattach the abductors [27].

23.11 Direct Open Augmented Repair with Synthetic Grafts or Allografts

In cases where the functional quality or the anatomic integrity of gluteal muscleis compromised, the tendon can be augmented with synthetic grafts or allografts. Prerequisite for an adequate augmented repair is the functioning glutei with a low-grade fatty infiltration (Goutallier grade <2) [28].

The standard positioning, approach and evaluation of the rupture are performed as previously described. Either a standard transosseous or suture anchor repair is performed. In case of short tendon length, a slightly proximal position and single-row technique could be used to avoid over tensioning of the repair. The synthetic graft or allograft is utilized to cover the repair site, ensuring the holding on healthy tendon proximally and healthy tendon or bone distally. Different types of synthetic grafts or allografts have been proposed:

(a) Synthetic Ligament

Following bursectomy, Y-iliotibial band release, debridement of the diseased tendon and decortication of the trochanteric footprint, the flattened portion of the synthetic ligament is sutured onto the undersurface of medius or reflected minimus, if involved. The GMed augmented with the synthetic ligament is reattached through a transosseous tunnel, together with suture anchors [29]. Bucher et al. [29] reported on the 1-year clinical and functional results of 22 patients with GMed and GMin tears that were augmented with Ligament Augmentation and Reconstruction System (LARS) synthetic ligament. All patients had failure of conservative treatment previously. There was a significant improvement at 12 postoperative months in the Oxford Hip Score, Short-Form Health Survey (SF-36) and a visual analogue pain scale (VAS) compared to the preoperative values. There was a minimal complication rate. All patients were at least satisfied with the procedure at the end of the first postop year.

(b) Collagen Patch

Following the repair of an abductor tear with transosseous tunnels or anchors, an appropriately sized nonabsorbable collagen patch can be secured over the repair with a running nonabsorbable suture [30]. In cases, with questionable distal fixation, the patch could be partly secured on the vastus lateralis tendon to enhance mechanical integrity.

Fink et al. [30] evaluated the postoperative outcomes of 30 patients with a mean age of 76 years suffering from large tears of the GMed. The patients were treated with osseous fixation using a modified Mason-Allen technique that was additionally secured by a nonresorbable collagen patch (Covidien, Trèvoux, France). Nine patients had a spontaneous tear of the gluteal muscle, and 21 had suffered tearing following hip replacement surgery using a transgluteal approach. At a mean of 24 months, the VAS, HHS and the GMed muscle force were significantly improved and 25 patients had mild or no limb at all. A degree of fatty degeneration of the muscle greater than 50% was related to suboptimal functional results.

(c) Achilles Tendon Allograft

In this technique, the fresh-frozen Achilles tendon with attached calcaneal bone allograft is used. The calcaneal bone block measuring 2 × 1.5 × 0.5–1 cm is fashioned with a saw appropriately with the most proximal edge bevelled to dovetail into a trough of the greater trochanter that was outlined to match the size of the allograft [31]. The fibrous remnants of the tendon insertion are cleaned to create a vascularized bed to increase integration. The GMed and GMin are then mobilized, and the interval between them is developed to allow inferior translation of the muscles. The tendinous part of the allograft is passing through the intact GMed almost 3 cm proximal to the ruptured end and then looped back on itself. Following maximum abduction of the leg, the bone block is placed into the trough of greater trochanter with a press-fit technique and secured with 16-gauge wire or cable placed around the bone block and the proximal part of the femur. Nonabsorbable sutures are used to secure the tendinous portion of the allograft to the GMin and the capsule anteriorly and the intact area of the GMed tendon in a similar fashion posteriorly [31]. Hip abduction brace (10 abuction-30 flexion) for 6 weeks with partial weight bearing is required.

Fehm et al. reported the functional results of seven patients that underwent reconstruction of a deficient abductor mechanism following THA with the aforementioned surgical technique. At a mean follow-up of 24 months, all but one patient had substantial improvements in both the Harris Hip and the pain score.

23.12 Reconstruction for Chronic End-Stage Abductor Tears Using Muscle Transfer

These are salvage techniques described to manage chronic end-stage abductor tears with remarkable tendon insufficiency or gluteal atrophy. Two main surgical techniques have been proposed using either gluteus maximus (GMax) [32–34] or vastus lateralis (VL) muscle transfer [35, 36].

(a) Reconstruction with Gluteus Maximus Transfer Flap

The original technique using the anterior part of the GMax to replace the deficient abductor was described and evolved by L. Whiteside [32, 33]. Whiteside recommended the use of the anterior half of GM alone or combined with Tensor Fascia Lata (TFL) sutured under the VL to manage abductor insufficiency in a native hip; a supplementary posterior flap from GM could be also used to treat THA instability [32, 33]. Whiteside showed the vast improvement of limping and pain in five patients with irreparable tears of hip abductors, using the previously mentioned method; however, this study did not report on functional scores and muscle strength. Chandrasekaran et al. demonstrated a simpler modification of the previous technique [34]; they transferred the anterior third of GM and the posterior third of TFL in a flap to the greater trochanter to manage irreparable abductor tears in three patients with satisfactory outcomes.

The authors' preferred technique is a more straightforward modification of the aforementioned surgical techniques and is described as follows:

The patient is placed in the lateral decubitus position. An incision 12–15 cm long centred over the greater trochanter is performed following the anatomic axis of the femur distally, slanting slightly posteriorly proximally. Following the dissection and retraction of the subcutaneous tissue, the conjoint aponeurosis of the GMax muscle and the fascia lata are exposed. A triangular flap including the anterior third of the GMax muscle is sharply divided anteriorly from the fascia lata and posteriorly in line with GMax fibres; this flap extends 12–15 cm roughly to the half of the length of the muscle (Fig. 23.5). The VL muscle is then incised

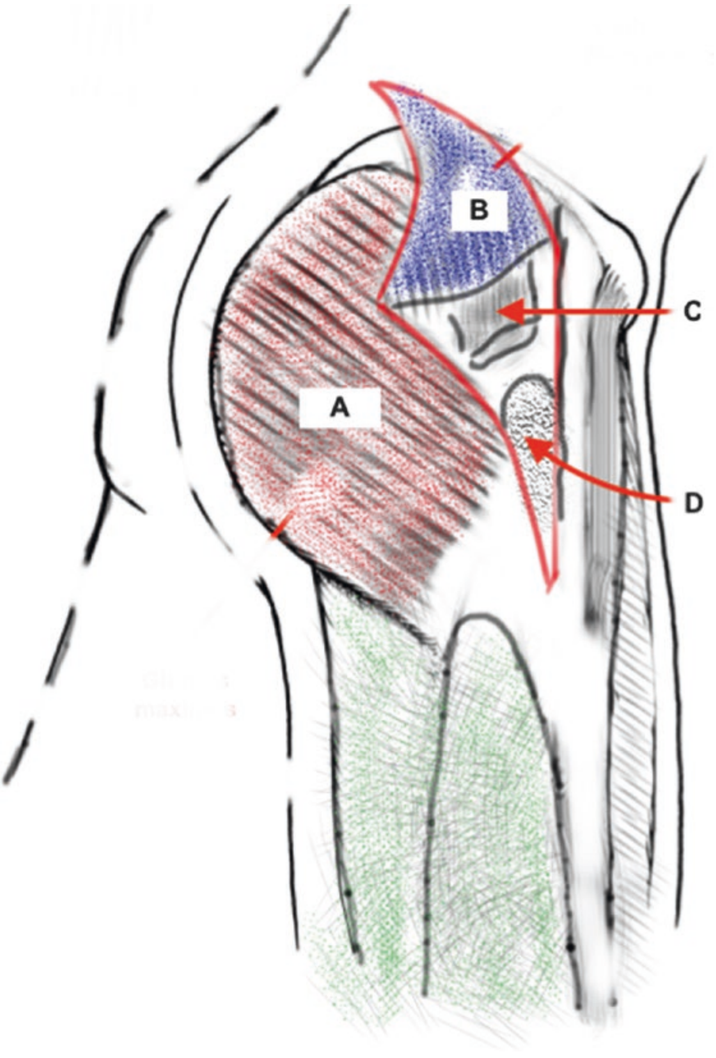

Fig. 23.5 Schematic representation of the lateral part of the gluteal and femoral region demonstrating the lifted triangular flap of the anterior third of the gluteus maximus muscle that uncovers the tear of gluteus medius and greater trochanter

off the vastus lateralis ridge, and the proximal part of VL is mobilized for 2–4 cm in length. The footprint of re-insertion of the GMax on the lateral side of the greater trochanter is then prepared using a round burr aiming to reveal cancellous bone to facilitate healing of the flaps. In case of a patient with THA, six 1.8-mm-diameter drill holes were made at the anterior and posterior margins of the footprint. Large nonabsorbable sutures are passed through the holes in a direction from inside-outside-inside and then through the GM flap where tightened, transferring the flap on the major trochanter with the hip in the abduction of 15–20°. When no hip implant is present, trying not to disturb the vascular supply of the femoral head, three 2.6 mm bio-composite corkscrew suture anchors double loaded with high strength sutures row are used at the anterior and posterior margins of the footprint to transfer and tightening of the flap to the greater trochanter (Figs. 23.6 and 23.7). Once the limb is reduced to a neutral position, pie crust incisions can be performed on the flap to obtain the proper tension. In the end, the upper part of VL muscle is slightly mobilized and sutured over the distal end of the flap of

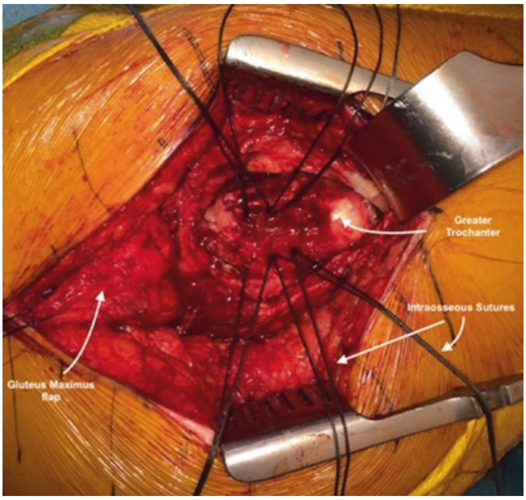

Fig. 23.6 Intraoperative picture displaying the prepared footprint of the greater trochanter, sutures in position and the lifted flap of gluteus maximus

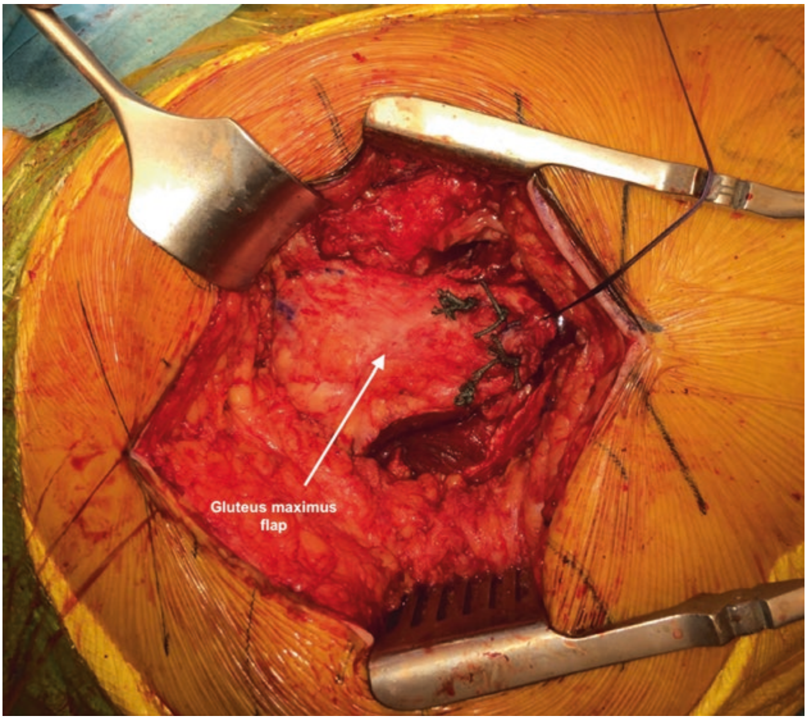

Fig. 23.7 Intraoperative picture showing the gluteus maximus flap that is stitched on the footprint of major trochanter

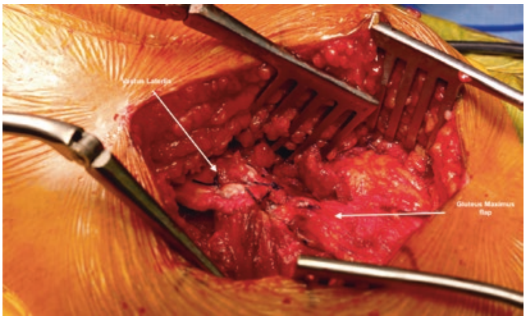

Fig. 23.8 An intraoperative picture illustrating the mobilized part of vastus lateralis covering the lower part of the transfer red gluteus maximus

GMax with absorbable sutures to form a united flap (Fig. 23.8). Postoperatively, the patient walks with partial weight bearing and two crutches for the first 8 postoperative weeks and no active abduction is allowed for 8 weeks. Physiotherapy initiates at 2 months postoperatively.

The authors retrospectively evaluated 38 patients with a mean age of 70.2 years who were surgically managed for chronic abductor insufficiency with the technique mentioned above. All patients had Trendelenburg sign, impaired muscle strength of abduction (≤M4) and fatty degeneration of muscles (Goutallier ≥3). Ten patients received the tendon transfer on a native hip, six following primary THA and 22 after revision THA. The mean VAS, HHS and the median abductor strength were significantly improved compared to the preoperative values. Two-thirds of the patients had a negative Trendelenburg sign at twelve postoperative months. No serious complications were reported.

(b) Reconstruction with VL Flap

This is the other salvage technique to manage nonreparable chronic end-stage abductor tears [35, 36]. Following a lateral incision across the whole length of the thigh, the iliotibial band is incised in line. Once the interval between rectus femoris and VL is developed, the entire VL is prepared taking care not to injure the neurovascular pedicle of the muscle. The muscle is best mobilized from proximal to distal. The plane between VL and the underlying vastus intermedius must be dissected carefully, and the nerve supply to the vastus intermedius must be preserved. Once the insertion of VL into the quadriceps tendon is divided, the muscle is mobilized, the neurovascular pedicle is followed to the femoral nerve, but left within the surrounding fatty tissue to protect it. The leg is abducted approximately 30°, and the VL is sutured proximally to the remaining abductors and with transosseous sutures to the proximal femur and the lateral intermuscular septum [35]. The patient postoperatively needs an orthosis for 6 weeks, and full weight bearing and abductor exercises are then allowed.

In a small series of 11 patients, the VL transfer demonstrated the moderate improvement of functional scores, pain and strength at 2-year follow-up [35]. The advantages of the method include the partial restriction of hip flexion, the separate neurovascular pedicle and the activation of VL in the same part of the gait cycle as hip abductors. However, the complex procedure, the decreased quadriceps muscle strength and the potential neurovascular damage due to overstretching of the neurovascular bundles are the main drawbacks [35, 36].

A proposed treatment algorithm for the management of abductor tendon tears is depicted in Fig. 23.9.

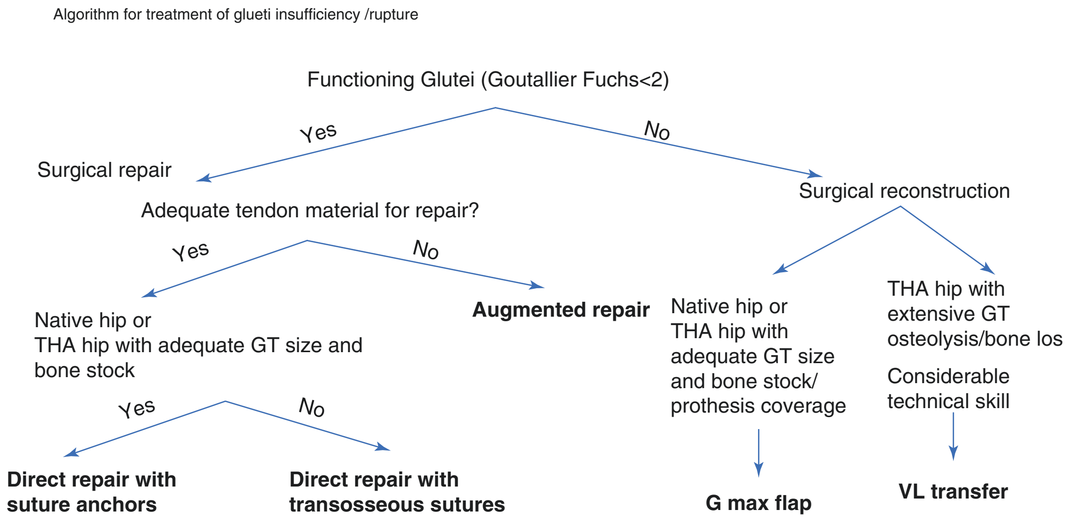

Fig. 23.9 A proposed treatment algorithm of abductor tendon tears

Tips and Tricks

Reinsertion

1. Do not reinsert neurologically nonintact muscles or fatty infiltrated gluteal muscles (Goutallier >2)
2. The lateral position of the patient is preferable.
3. A standard incision is advised to understand the pathology of tendons
4. When rupture is not evident at first sight then inject of saline under the insertion of gluteal tendons or split GMed fibres in line to gain access to the undersurface of the tendon and evaluate the extent of the rupture. Before splitting the muscle, place sutures into the opposite tendon sides to help with the anatomic repair.
5. Avoid an aggressive debridement in cases of severe tendinosis to preserve the maximal tendon length and width.
6. Do not remove excessive bone from the bone bed area of major trochanter to avoid microfractures and weakening of bone adjacent to anchor holes.
7. Use anchors instead of tunnels in case of a native hip aiming not to disturb the vascular supply of the femoral head.
8. Use four pairs of bone tunnels on the lateral facet for full ruptures of the GMed, perpendicularly to the long axis of the footprint.
9. Perform an additional pair of tunnels for GMin tears on the anterior tubercle of the greater trochanter, obliquely to the long axis of the femur.
10. Prefer thick nonabsorbable pull sutures
11. Place two to three proximal anchors in a proximal row and other two distally to serve for the double row effect.
12. Check the tension of the repair with the leg in the abduction of about 20–30°.
13. Perform blunt release of the glutei taking care to avoid the superior gluteal nerve or fascia lata elongation when necessary.
14. Postoperatively avoid full weight-bearing and active hip abduction for 6 weeks

Transfer

1. Transfer muscles to manage chronic end-stage abductor tears with remarkable tendon insufficiency or gluteal atrophy

2. Gluteus maximus transfer is considered less complicated technique than vastus lateralis muscle transfer
3. For the author’s preferred technique of gluteus maximus
    - (a) Place the patient in the lateral decubitus position
    - (b) Perform an incision 12–15 cm long centred over the greater trochanter following the anatomic axis of the femur distally, slanting slightly posteriorly proximally.
    - (c) Do not extend the flap of Gluteus maximus more than the half of the muscle (roughly 12–15 cm)
    - (d) Do not mobilize vastus lateralis more than 2–4 cm in order not to risk the nerve supply of the muscle
    - (e) Use anchors instead of tunnels in case of a native hip aiming not to disturb the vascular supply of the femoral head.
    - (f) Pie-crust the flap to achieve the proper tension of the flap with the leg in neutral position
    - (g) Try to achieve a united flap between gluteus maximus and vastus lateralis
    - (h) Postoperatively avoid full weight-bearing and active hip abduction for 8 weeks

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Open Adductor Tenotomy

24

C. Aletto and N. Maffulli

24.1 Epidemiology

Chronic adductor longus tendinopathy (CALT) is very frequent in athletes, with an incidence of 10% of all sports-related pathologies in the age group between 22 and 30 years [1]. CALT is usually associated with sports characterized by excessive use of the proximal muscles of the lower limb and abdominal muscles [2], such as soccer, hurdling, skiing, hockey, and rugby [3, 4]. In soccer, the incidence of CALT varies between 10 and 18% of all time-loss injuries [5]. Male athletes are more frequently involved than female ones [6, 7]. There are some intrinsic risk factors and extrinsic risk factors that predispose athletes to insertional tendinopathy of the adductors. The main intrinsic factor, directly related to the athlete, is strength imbalance between the adductor with muscle injury and the abdominal muscles. The main extrinsic factors, not directly related to the athlete, are incorrect or insufficient athletic training, unfavorable conditions of the playground, and unsuitable footwear [8].

24.2 Anatomy

All adductor muscles (excluding sartorius) originate proximally into the pubic arch near to the obturator internus muscle. The adductor longus attaches on the pubis anteriorly through tendon fibers (40%) and posteriorly through muscular fibers (60%); its insertion is on the linea aspera of the femur. The adductor brevis and adductor magnus muscles are located deep to the adductor longus with an essentially muscular proximal attachment. The adductor brevis inserts on the upper part of the linea aspera, while the adductor magnus inserts on the adductor tubercle on the medial condyle of the femur and on the medial lip of the linea aspera. The gracilis is the most medial muscle of the adductor group and attaches inferiorly to the adductor brevis and adductor longus on the anterior margin of the symphysis pubis and on the medial third of the inferior ramus of the pubis; it forms the pes anserinus with sartorius and semitendinosus. The sartorius originates from the upper half of the iliac notch, while the pectineus attaches more proximally on the pubic crest supero-laterally to the pubic tubercle and inserts

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on the posterior surface of the femur, from the lesser trochanter to the linea aspera [9, 10].

24.3 Pathophysiology

The origin of adductor tendinopathy is not easy to identify, particularly when it is chronic [11–14]. In the mechanical theory of tendon injury, the "overload" of the tendon tissue is central to the pathologic process. Tendons may not be able to respond adequately to overloaded, repeated, and prolonged stress, so microscopic trauma can occur within the tendon [15]. This repetitive microtrauma can eventually lead to cell and matrix changes, altered mechanical properties with possible symptoms. Although the effect of overload on tendons is detrimental, not loading a tendon is also implicated as a cause of tendinopathy. The vascular theory of tendinopathy suggests that tendons generally have a poor blood supply and that they are particularly vulnerable to vascular compromise in specific areas. The neural theory suggests that some mediators, such assubstance P and calcitonin gene-related peptide, are involved in tendinopathies [16–19].

The pathogenesis of Adductor Tendinopathy (AT) includes torsion and traction of abdominal and adductor tendons caused by rapid acceleration or deceleration, kicking and changes of direction [20, 21]. Maximal tensile load leads to tendon ischemia, and reperfusion generates oxygen-free radicals which may cause tendon damage [22, 23]. Generally, adductor dysfunction follows adductor tears, which determine acute pain [24]. The tendinitis can progress from an acute inflammatory injury to a degenerative process (tendinosis) with chronic degenerative changes of the connective tissue. Fibrosis and calcifications are compatible with a failure of the physiological processes of healing, resulting in inefficient cycles of attempts at repair [25, 26]. Moreover, the biomechanical properties of the tissue are altered by histological abnormalities of the enthesis and symphysis, with sclerosis and irregularities [3, 27]. AT generally produces groin pain, but sometimes the pain can radiate to the abdomen; the reason is that the deep insertion of the adductor longus attaches to the tubercle of the pubis via tendon fibers only, and the adductor longus and the rectus abdominis attach in continuity through a single common sheath. This common aponeurosis unites with the underlying capsule of the symphysis pubis and fibrocartilaginous disk. These anatomical findings justify why pain can radiate from the involved structure and spread proximally into the abdomen or distally into the thigh [28, 29] (Fig. 24.1).

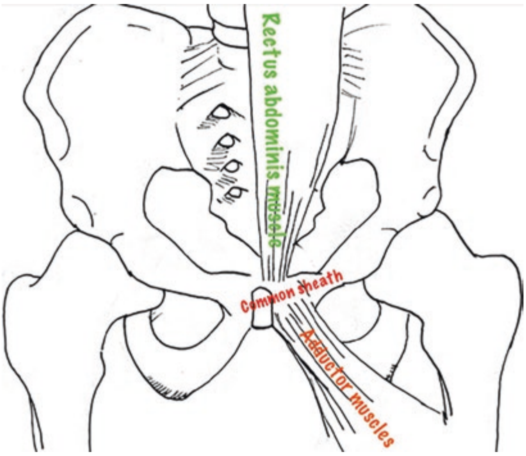

Fig. 24.1 Common sheath of rectus abdomen and adductor muscles

24.4 Clinical Features

Many athletes present to clinicians with a history of unilateral groin pain, which may be acute or chronic, localized tenderness, and weakness. Patient may give a history of a single traumatic event or repeated microtrauma to the region. Groin pain occurs at the proximally portion of the adductor muscles and can radiate distally to the leg. It increases with activity such as pivoting, cutting, and skating. In addition, compensatory mechanisms may result in symptoms extending to the rectus abdominis insertion and/or to the opposite groin. There is increasing pain after activity and tenderness the following day [30].

The severity of pain could be scored according to the functional classification of Puffer and Zachazewski. This classification includes four stages:

- stage I: pain arising only after physical activity;
- stage II: pain during physical activity, without any restriction of performance;
- stage III: pain during physical activity, with restriction of performance;
- stage IV: chronic and unremitting pain [31].

In acute cases (grade I and II), patients report a very intense pain in the groin area, like an unexpected stab with a knife, and local hemorrhage. A few days after the injury, gradual appearance of swelling and hematoma can be seen on the medial aspect of the upper third of the thigh, and patients report localized tenderness and difficulties to contract the hip adductors. Complete muscle tears (grade III) strains occur in the distal musculotendinous junction located toward the insertion on the femur. In chronic cases, the symptoms are more multifaceted and atypical. Pain can be more or less diffuse, localized over the tendon area of the adductor longus. With time, pain can radiate distally along the medial aspect of the thigh or proximally toward the rectus abdominis. However, the symptoms can be vague and diffuse.

Functional deficits can lead to severe impairment of different motor tasks, such as twisting and kicking movements while running, and to the cessation of athletic activities [5, 32].

24.5 Clinical Diagnosis

A complete clinical examination is required. The patient should first be examined standing to evaluate the conformation of extremities (knee axis and patella orientation) and potential inguinal or sports hernias. Observation from the back is important to assess the symmetry of the pelvis, shoulders, asymmetry of the trunk, and posterior superior iliac spines. Furthermore, the assessment of foot stance, hindfoot, and forefoot is performed. Subsequently, mobility on all planes of the lumbosacral spine should be performed, excluding the presence of scoliosis. Lateral examination of spinal curvatures, rotation of the pelvis, and posture of hips and knees should be performed. Indeed, many patients with adductor tendinopathy syndrome present lumbar hyperlordosis with pelvis anteversion [8]. The patient should then be placed supine to assess the motion of the hip joint and the function of the hip muscles. Resisted contraction of the knee extensors, knee flexors, and abdominal muscles should be performed. If the adductor longus muscle is injured, pain will be elicited by resisting leg adduction and in passive stretching at full abduction of the hip [33]. Evaluation has to be performed bilaterally. Specific tests show loss of extension (test of Thomas), the posterior chain (FABER test), and sacro-iliac joint (test of Gaenslen).

Pain is exacerbated by palpation of the attachment of the adductor longus on the pubic tubercle (unilaterally or bilaterally) as well as by the counter resistance contraction of the muscle [3, 24].

The clinical diagnosis of AT can be reliably made if three test findings are positive: tenderness at the adductor longus origin, pain on passive stretching of the adductors, and pain on adduction of the thigh against resistance [34].

24.6 Imaging Assessment

The clinical diagnosis of AT can be confirmed by advanced imaging to definitively exclude the many other possible anatomical structures which can produce groin pain [35]. On plain radiographs of the hip joint, patients show normal findings, with no evidence of femoroacetabular impingement, fractures, avulsion injury, or calcification. The assessment of symmetry of the hips, pelvis, and tendon insertional area, pathologies such as arthrosis, fractures, or lytic lesions is required. Standing antero-posterior pelvic radiographs are useful to reveal hip osteoarthritis, sclerosis, and remodeling of the symphysis pubis. When using ultrasonography, the patient is examined with a linear transducer while supine with the thigh abducted 30°, externally rotated and the knee flexed. Longitudinal and axial images are obtained and then compared to the contralateral side. Thickness and contour should be evaluated, and normal echostructure could be replaced by hypoechoic changes, a sign of swelling. The most specific sign is an anechoic intratendinous tear with discontinuity of fibers within the otherwise well-organized fibrillar tissue [36]. Vascularity is also considered important in tendon disease, and an increase in Power Doppler signal is related to inflammation and neovascularity. Dynamic evaluation rules out partial tears. MRI offers excellent soft tissue contrast, multiplanar capability, lack of ionizing radiation, and is sensitive to small injuries. MRI excludes intra-articular hip joint disorders, such as labrum tears and chondral lesions, other than osteitis pubis and iliopsoas strains/bursitis. MRI of normal tendons shows low signal intensity on all pulse sequences, while a tendinopathic tendon is normal or enlarged and has high signal [37]. The abnormal tendon is compatible with degeneration and micro tears, as they generally coexist. There is also edema that runs from the myotendinous junction along the muscle fascicles. Second-degree muscle strains will show a hematoma at the myotendinous junction along with increased fluid adjacent to the fascicles. Third-degree strains demonstrate complete disruption of the myotendinous unit [38]. In enthesopathy, MRI will show an abnormal increase in signal in the region of the adductor long synthesis, periostitis, and adjacent marrow edema [27]. Calcified tendinopathy or bony abnormalities at tendon insertions are better visualized by CT [39].

24.7 Differential Diagnosis

Numerous conditions may manifest with symptoms similar to injuries to the adductor muscles [4]. The adductor longus muscle accounts for up to 62% of groin injuries [40]. In athletes, groin pain that actually involves adductor muscle pathology can present in various forms: muscle strain, tendinopathy, enthesopathy, paratenonitis, or a combination of them [28]. Muscle strain, musculotendinous strain, and tendinopathy disorders responds well to rehabilitation therapy, whereas micro-tears at the tendon-periosteal junction and enthesopathy often progress to prolonged chronic groin pain [27]. Differential diagnosis for chronic groin pain includes osteitis pubis, sports hernia, and femoroacetabular impingement. Osteitis pubis (or “Sportsman’s hernia”) is a degeneration of the pubic symphysis with tenderness on palpation of the symphysis and instability of both the hemi-pelvises. The diagnosis of sports hernia, inguinal, or femoral includes any combination of a torn external oblique aponeurosis, a torn conjoined tendon, and dehiscence between the conjoined tendon and the inguinal ligament [41]. Other potential causes of groin pain are tears of quadrates femoris and obturator externus, hip joint disorders, such as femoroacetabular impingement [42], chondral lesions, and labrum tears; nerve entrapments, involving the ilioinguinal, iliohypogastric, or genitofemoral nerves; iliopsoas strains/bursitis; stress; and avulsion fractures [3]. Lumbar disc or facet joint abnormalities may result inradicular symptoms referred to the pelvis or groin. Symptoms from ilioinguinal or genitofemoral nerve roots may be provoked with slide or femoral nerve stretch tests [43]. In addition, provocation of lumbar facet joints can induce pain in the distribution from L2 to L5 [44]. Bursitis, after direct blunt trauma or as the result of chronic irritation secondary to friction syndromes, can cause groin pain in many athletes. Groin pain can result from irritation to the bursa between the iliotibial tract and the greater trochanter, subgluteusminimus, medius, and maximus bursae along with the sub-iliopsoas bursa [45, 46]. In some cases, groin pain may arise from urogenital pathologies such as prostatitis, varicocele, epididymitis, hydrocele, and salpingitis [47].

24.8 Treatment

Nonoperative management for persistent pain consists of rest, ice, medications, and physical therapy. When the pain is refractory to conservative treatment, local steroid injections of the adductor origin and dextrose prolotherapy [48, 49] have been proposed. At 1-year follow-up, local steroid injection is effective only in 68% and 33% of the recreational and competitive athletes with adductor tendinopathy, respectively [27, 34]. On the other hand, multiple injections of 12.5% dextrose and 0.5% lidocaine allow return to sport in about 90% of elite athletes with groin pain [48, 49].

Platelet-rich plasma (PRP) injections under ultrasound guidance can be used to accelerate recovery by enhancing tend on healing and are not associated with any specific risks [50–55].

Laser therapy (pulsed Nd-YAG laser), diathermy, or heat therapy with resistive to capacitive system, extracorporeal shock wave therapy can favorably promote tendon regeneration.

During the acute phase, rehabilitation measures include stretching, postural balance techniques and, if necessary, global postural re-education. Proprioceptive orthotics insoles can improve coordination and joint stability by modifying the intensity and level of muscle activity. Decontracting massage therapy can help relax tight muscles, increase local circulation, and reduce pain. In the early stages, physical therapy consists of isometric strengthening of the abdominal and adductor muscles. In all rehabilitation phases, neuromuscular taping is useful to promote muscle relaxation and protect muscle-tendon units from over-stretching. In the subacute phase, muscle strengthening is increased by cardiovascular reconditioning and by eccentric and concentric exercises. In resistant and chronic cases, transverse friction massage promotes optimal collagen healing by increasing microcirculation and decreasing collagen cross-linking. Core stability exercises using the Swiss Ball are useful in the contextual and synergic strengthening of abdomen, adductor, and lumbar muscles [56, 57]. Finally, running is gradually reintroduced. In the return-to-sport phase of rehabilitation, aerobic running with increasing speed is associated with short but intense anaerobic training, stretching and repeated exercises are introduced and, subsequently, exercises with sprints and jumps are proposed. At the same time, athletes begin to practice again with the ball to recover the neuromotor information of specific sport actions. Postural, eccentric strengthening, and plyometric exercises are important for the return-to-sport phase to maintain a good stretch of the posterior chain and the adductors muscles and a good balance between agonist and antagonist muscle groups [55, 56].

If conservative measures have failed for at least 3-month surgical intervention may be proposed. Surgical treatment for chronic adductor tendinopathy refractory to nonoperative management and local steroid injections consists of adductor longustenotomy [40, 60, 61]. For this procedure, a small skin incision of approximately 3 cm is made over the prominence of the adductor longus tendon. After dissection of the covering layers, the tendon component of the adductor longus is resected; this does not have a functional impact in the long term [36].

Schilders et al. reported a selective partial adductor longus release for long-standing adductor-related groin pain in a group of professional soccer and rugby players. The procedure is performed under general anesthesia and antibiotic prophylaxis. The patient is positioned in the frog-leg position. A transverse incision is made below the scrotum. The fascia of the adductor longus is divided to identify the tendon, and a transverse incision is made 2–4 cm distal to the origin. Thus, the procedure involves a partial tenotomy, which is performed only on the superficial fibers, which are under relatively greater tensile loads. The compressive bandage is removed 2 days postoperatively and replaced by compression tights, which athletes are advised to wear until returning to sport. The patients follow a standard rehabilitation program with a closed chain adductor strengthening exercise program 2 days after the operation. Straight-line jogging begins after 7–10 days. Open chain adductor strengthening exercises start when the closed chain adductor strengthening exercises can be performed pain free [62].

Maffulli et al. proposed a surgical approach consisting of bilateral adductor longus tenotomy, despite the presence of unilateral symptoms, to prevent unbalancing of the pelvis from the unopposed action of the remaining intact adductor [63, 64]. The surgical procedure is performed under general anesthesia. Prophylactic 2 g of cefazolin is administered intravenously at induction. Patients are supine with the hip flexed to 90°and maximally abducted to put the adductor longus tendon under tension. A 2-cm transverse incision is performed in the groin region and a complete tenotomy is performed approximately 1 cm distal to the origin of the adductor longus on the pubis. Accurate hemostasis is performed to avoid the formation of blood collection when required. At the end of the procedure, the subcutaneous tissues and the cutaneous incision are closed with reabsorbable sutures (Fig. 24.2).

If the preoperative infection control procedures are not applied, as in all surgical procedures, tenotomy of the adductor longus can be complicated by an infection (Fig. 24.3).

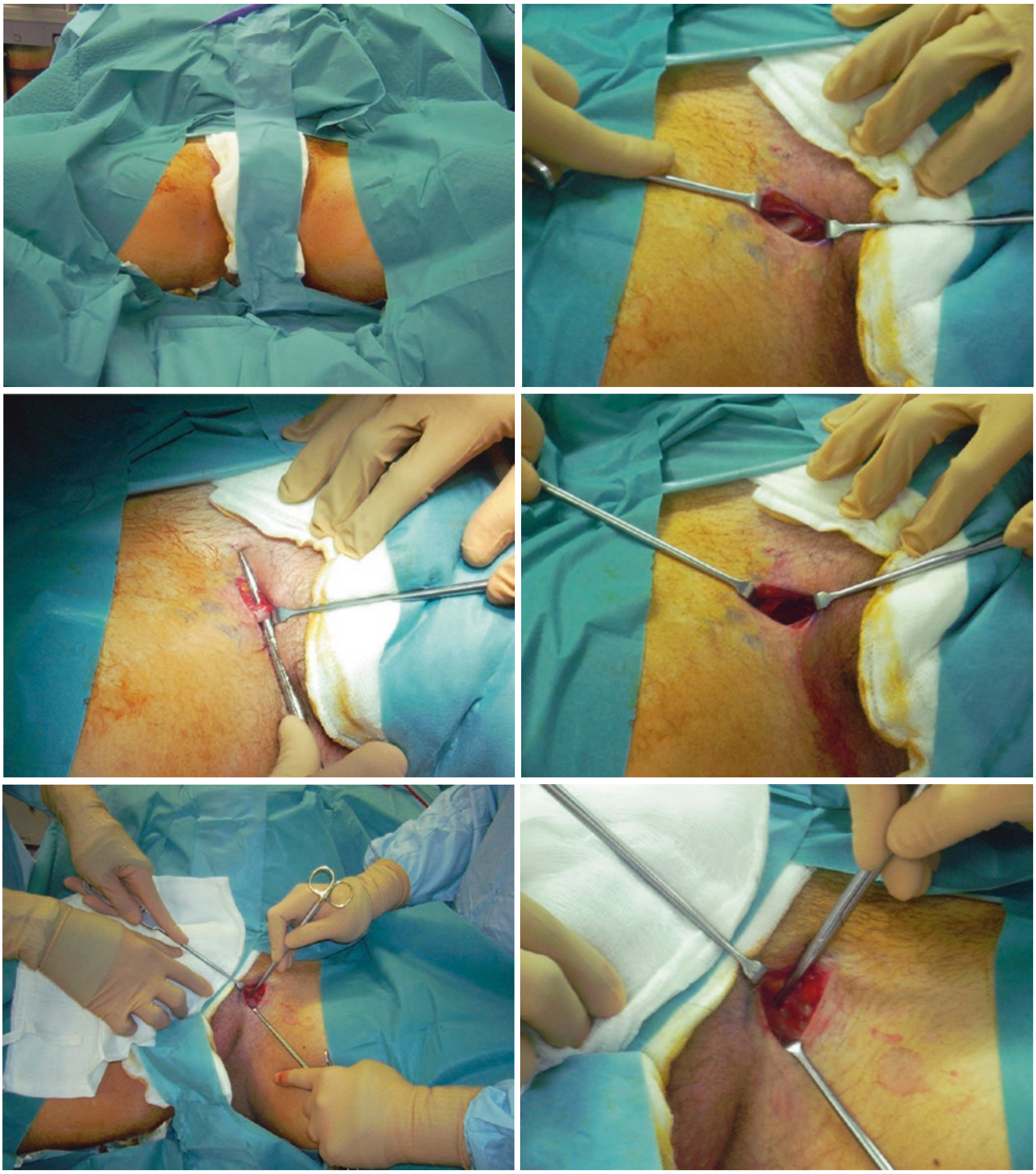

Fig. 24.2 Bilaterally approach

Fig. 24.3 Cases of surgical infections

Postoperatively, patients undergo a physical therapist-assisted rehabilitation program. The first week includes regular icing for 10 min twice a day. During the second week, gentle adductor stretches to tightness is performed as tolerated. From the third to the sixth week, progressively increasing adductor resistance training is added in association with a graduated re-introduction of walking, jogging, and agility training. Kicking and sprinting are not attempted before 8 weeks, competitive training is introduced at 10 weeks and competitive sport is not recommended before 16 weeks [34].

Another therapeutic approach to consider is intratissue percutaneous electrolysis (EPI®). This is an ultrasound-guided minimally invasive technique that makes it possible to degrade the diseased tissue through the electrolytic action of electrochemical ablation as well as to develop an extremely localized inflammatory process that can induce the healing process [65]. EPI® treatment in association with active physiotherapy could be more effective [66]. However, long-term independent studies on this technique are lacking.

Tips and Tricks

- Chronic tendinopathy of the adductor tendons involves especially the adductor longus
- Athletes with adductor longus tendinopathy present to clinicians with a history of unilateral chronic groin pain
- The clinical diagnosis can be formulated if three test findings are positive: tenderness at the adductor longus origin, pain on passive stretching of the adductors, and pain on adduction of the thigh against resistance
- Ultrasonography is indicated as the first imaging modality followed by a MRI if doubts still exist
- Nonoperative management for persistent pain consists of rest, ice, medications, physical therapy and, when pain is refractory, local injection of steroids or dextrose prolotherapy
- If conservative measures have failed for at least 3 months, surgical intervention (unilateral or bilateral adductor longus tenotomy) may be proposed
- The surgical procedure is performed under general anesthesia, patients are supine with the hip flexed to 90°and maximally abducted, a 2-cm transverse incision is performed in the groin region and a complete tenotomy is performed approximately 1 cm distal to the origin of the adductor longus
- Postoperatively, patients undergo a physiotherapy rehabilitation program
- The most common cause of failure of well performed surgery is attempts at too early return to sport

24.9 Conclusion

CALT is very common in sports and is accompanied by a nonspecific symptom, namely groin pain. The clinical diagnosis (history, symptomatology, physical examination), followed by a careful imaging, is very helpful to identify CALT as soon as possible and to implement early management. The latter may include conservative treatment and, if refractory, surgical treatment with partial or complete tenotomy. Surgical approach may include a bilateral tenotomy to prevent pelvis imbalance. Early treatment reduces risk of losing training or working days and ensures return to sport activity.

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Psoas Tenotomy

25

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25.1 Anatomy

The iliopsoas muscle is formed by the fusion of three distinct muscles: the iliacus, psoas and iliocapsularis [1]. The first two muscles unite at the inguinal ligament level to form the iliopsoas muscle with a common fascia. The iliocapsularis muscle is a deep muscle bundle originating from the anterior–inferior iliac spine that lies on the anterior capsule of the hip joint. The common insertion has an inverted teardrop shape, occupying the entire posterior surface of the lesser trochanter and extending to the femoral shaft. The superior margin of the iliopsoas insertion is closely related to the inferior-most insertion of the hip joint capsule [2].

Anatomical variations occur and mostly consist of multiple insertions. In a series of patients who underwent endoscopic release for non-arthroplasty iliopsoas impingement, these were encountered in up to 17.8% of the cases [3]. An incomplete surgical release therefore occurs and may lead to persistence of symptoms [4–6].

25.2 Pathophysiology

There are two main mechanisms of iliopsoas impingement in two completely different cohorts of patients. In those patients that have undergone a total hip replacement (THR), the iliopsoas can abut against an anterior oversized socket (Fig. 25.1).

On the other hand, non-arthroplasty iliopsoas impingement usually occurs in athletes or dancers and involves the iliopsoas producing a painful and audible click when the hip is moved from a flexed and externally rotated position to an extended and internally rotated position. The mechanism behind this clicking is the abutting of iliopsoas tendon against the femoral head or the iliopectineal eminence in that specific position. This can also lead to a repetitive, mechanical abutment of the musculotendinous junction on the adjacent labrum (Fig. 25.2), more specifically at the 3 o'clock position in the right hip and 9 o'clock position in the left hip leading to labral pathology [7–9].

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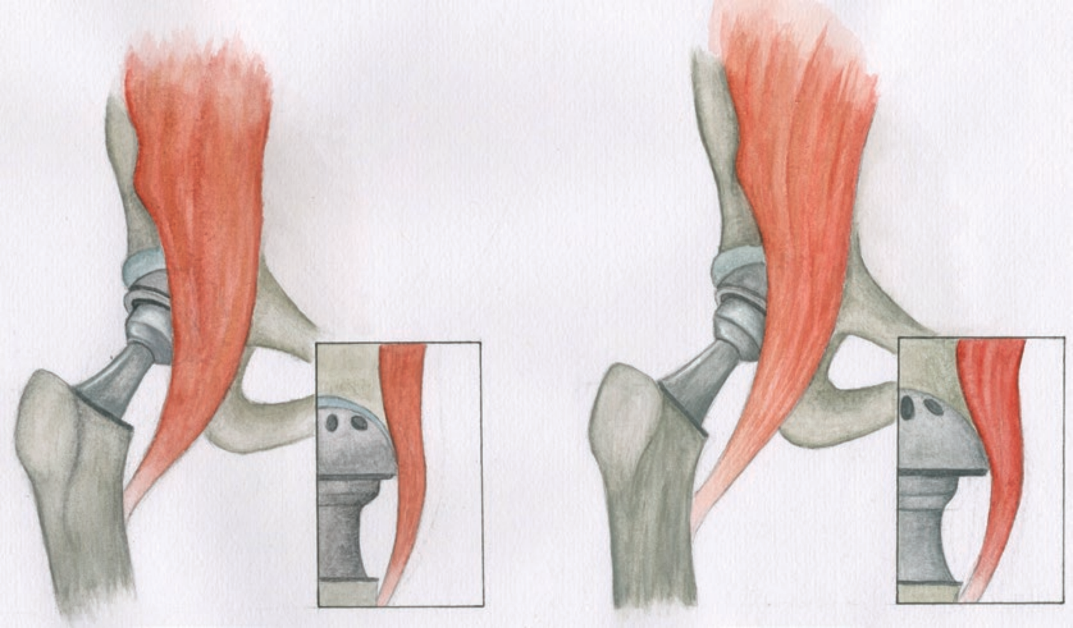

Fig. 25.1 The iliopsoas abuts against a large acetabular component of the prosthesis

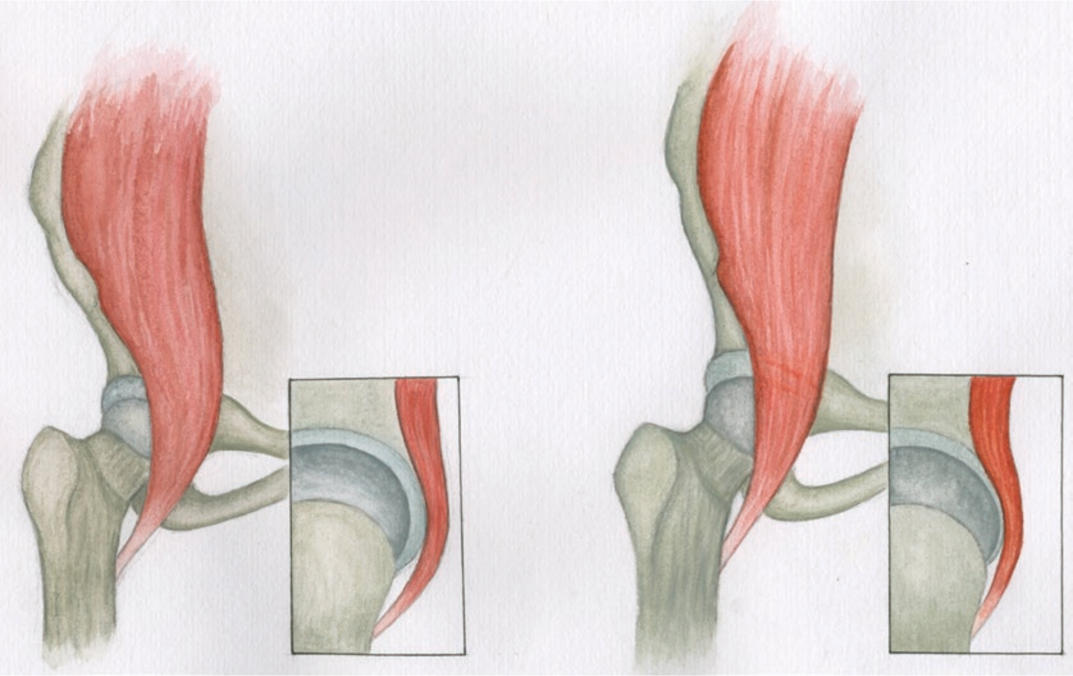

Fig. 25.2 The iliopsoas rubs against the anterior labrum at the 3 o'clock position

25.3 Clinical Presentation

Clinical examination in these patients may reveal a series of positive findings: focal tenderness over the iliopsoas tendon at the anterior joint line and pain on resisted hip flexion for THA-related pathology or positive C-sign, positive FADIR / hip impingement test and positive FABER / Patrick's test for the athlete-related condition. However, none of these tests are specific to iliopsoas pathology, as they are present in many other hip conditions as well [10].

Assessment of chronic groin pain demands a very thorough approach and accurate clinical judgement. Hip joint pathology is the most common clinical entity responsible for groin pain (55.98%), further consisting of femoroacetabular impingement (40%), labral tears (33%) and osteoarthritis (24%) [11].

However, a study including 4655 subjects revealed a different distribution among a population including only athletes: femoroacetabular impingement (FAI) (32%), athletic pubalgia (24%), adductor-related pathology (12%), inguinal pathology (10%) and labral pathology (5%) [12].

This contrast between the general population and athletes indicates the importance of a detailed history with a comprehensive clinical examination to ensure differentiation of overlapping aetiologies [13–15].

It is also important to distinguish snapping from painful snapping, because snapping alone is not pathological. Snapping or clicking are common and occur in up to 40% of patients without any associated pain [16].

25.4 Investigations

25.4.1 Plain Radiographs and Computed Tomography

These tests are helpful in diagnosing the arthroplasty-related iliopsoas impingement and also revealing undercoverage or borderline dysplasia in non-arthroplasty iliopsoas impingement. Generally, there is a prominence of the acetabular component on true cross-table lateral radiographs and CT scans of the hip [17]. Also, no other evidence of infection or loosening of the components which would explain the symptoms has to be noted.

25.4.2 Ultrasonography

Ultrasonography is a noninvasive way of successfully visualizing the iliopsoas tendon [18]. This allows the longitudinal evaluation of the distal iliopsoas complex—from the hip joint to the lesser trochanter [39]. Dynamic sonography has also been described and can achieve real-time observation, as the tendon can be seen snapping over the iliopectineal eminence. Despite limited data and the unavailability of ultimate specificity and sensitivity, promising results can be observed, as bifid tendons or an increased diameter of the muscle belly as well as underlying labral cysts can sometimes be identified [18].

Apart from diagnosis, there is also therapeutic potential with this technique [19]. In a study with clinically presumed iliopsoas impingement, 64% of patients achieved an immediate relief whilst 44% continued to remain pain-free for up to 1 year following the ultrasound-guided injection [20].

25.4.3 Magnetic Resonance Imaging (MRI)

Non-arthroplasty iliopsoas impingement can potentially lead to a localized labral tear at the 3 o'clock position in the right hip and 9 o'clock position in the left, which can be identified conclusively on the MRI scan [8].

25.4.4 Diagnostic Intra-Articular Injection

The diagnosis of non-arthroplasty iliopsoas impingement can be challenging. There is usually concomitant intra-articular pathology or FAI that can be responsible for the patients' symptoms. The intra-articular diagnostic hip injection is very helpful in these cases [21]. Patients with chondral damage have greater relief from intra-articular injections than those without chondral damage, regardless of severity [22]. Also, this procedure is very useful in distinguishing intra from extra-articular pathology. A negative test in patients with non-arthroplasty iliopsoas impingement can rule out intra-articular causes and suggest that the pathology mainly exists in the iliopsoas tendon itself.

25.5 Management: Physical Therapy

Conservative therapy may not always be of help in patients with arthroplasty related iliopsoas impingement because the main issue is of a mechanical overhang of the acetabular component rim and irritation of the iliopsoas tendon. Chalmers et al [23] have established a limit of 8 mm of acetabular rim prominence to be a decision making point in terms of whether non-operative treatment would be of help. However, in patients with non-arthroplasty iliopsoas impingement, conservative therapy is of immense help with positive outcomes. Laible et al. [24] used a conservative regimen that implied activity-specific rest, oral NSAIDs, comprehensive physical exercises (progressive iliopsoas strengthening, pelvic mobilization, anti-lordotic exercises) and achieved a full relief of symptoms in 100% of the patients [24]. Other conservative regimens have shown evidence of only partial relief in both arthroplasty-related [25] and non-arthroplasty related iliopsoas impingement [26, 27]. To the best of our knowledge, there are currently no physiotherapy regimens with proven efficacy that can be standardized for all populations.

25.6 Management: Surgery

If conservative therapy fails, then patients should be put forth for surgical management. Surgical management involves release or fractional lengthening of the iliopsoas tendon which can now be performed arthroscopically as opposed to the standard open technique [28, 29]. Arthroscopic release can be performed at different anatomical levels (Table 25.1) [30]. A release at the level of the labrum was able to achieve pain relief in up to 77% (Nelson) [29] or 82% (El Bitar) [28] of cases after 2 years of follow-up. Resecting 45% of the tendon-muscle belly complex at the level of the labrum is sufficient in order to release the entire tendinous portion [9]. This appears to be a superior option than releasing the iliopsoas tendon at the level of the lesser trochanter [30].

Biomechanical studies [31] also show evidence of improved iliopsoas excursion after decompression of the AIIS (anteroinferior iliac spine). This technique may improve iliopsoas motion while maintaining the integrity of the footprint of the rectus femoris, if the resection is less than 10 mm [31]. Further techniques of fractional lengthening have been described but studies reporting on long-term efficacy are lacking [32].

We describe the senior author's preferred technique in the next section.

Table 25.1 Iliopsoas composition at different anatomical levels

Anatomical level	Muscle belly circumference (mm)	Tendon circumference (mm)	MTU composition (percentages)
Labrum	41	27	60% muscle belly 40% tendon
Transcapsular	27	31	47% muscle belly 53% tendon
Lesser trochanter	19	27	40% muscle belly 60% tendon

MTU muscle tendon unit

25.6.1 Surgical Technique

After appropriate consent, the patient is anaesthetized using a general anaesthetic and positioned in a lateral position using the Smith and Nephew lateral distractor. A trial of traction is applied using the image intensifier to ensure that the joint can be distracted which is then reduced and the patient is prepped with non-alcoholic betadine and draped with a clear drape.

The hip joint is then distracted under image intensifier (II) control, and the traction is applied to the leg until the suction effect is seen on the II and then a 17 G needle is introduced into the joint to equalize the pressure in the hip with the atmospheric pressure. Following this, the joint is easily distracted and 40 mL of normal saline is injected to further distend the joint. At this stage, the silhouette of the acetabular labrum is clearly visualized which serves as a guide to needle and furthermore portal placement. The needle is now reinserted to avoid piercing the labrum. Care should be taken at this point as an incorrect needle trajectory can pierce the labrum. A guidewire is then introduced via the needle, and the anterolateral portal is established over the guidewire. A 70° arthroscope is used for visualization of the central compartment. A second modified distal and anterior portal is then established under direct vision. A fluid management system is of paramount importance for obtaining a good view of the hip. With the current systems, pressures as high as 70 mmHg are required to obtain a good view of the central compartment and approximately 50 mmHg to view the peripheral parts of the joint.

A diagnostic round is performed visualizing the entire labrum, the ligamentum teres, articular surface of the acetabulum in its entirety and all pathology identified. A transportal capsulotomy is then performed depending upon the need and all identified pathology addressed. Following capsulotomy, arthroscopic signs of iliopsoas impingement which include hyperaemia or macroscopic degeneration of the tendon and/or a labral tear at the 3 o'clock position in the right hip. Once confirmed, the fractional lengthening of the iliopsoas tendon is performed via the central compartment at the level of the labrum under direct vision with the capsulotomy blade. Care should be taken at this stage so as not to release beyond the tendon, especially when the red fibres of iliacus are visualized to avoid any neurovascular injury (Fig. 25.3a–c). Following this, the AIIS is assessed and if there are any signs of impingement, the AIIS is burred with a 4-mm burr under direct vision to allow a better excursion of iliopsoas. The labral tear is then addressed and repaired with anchors or debrided as necessary. Following this, the traction is released, and the cam impingement lesion addressed via the peripheral compartment. The osteochondroplasty is performed under direct vision and a dynamic impingement test is carried out on the table to ensure there is no residual impingement. Haemostasis is achieved with the radiofrequency probe, and the camera and instruments are withdrawn and all the remnant fluid is sucked out of the joint. Skin is closed using 3-0 Nylon, and 40 mL of 0.25% Chirocaine is used in the portal sites for postoperative pain relief. A pressure dressing is applied.

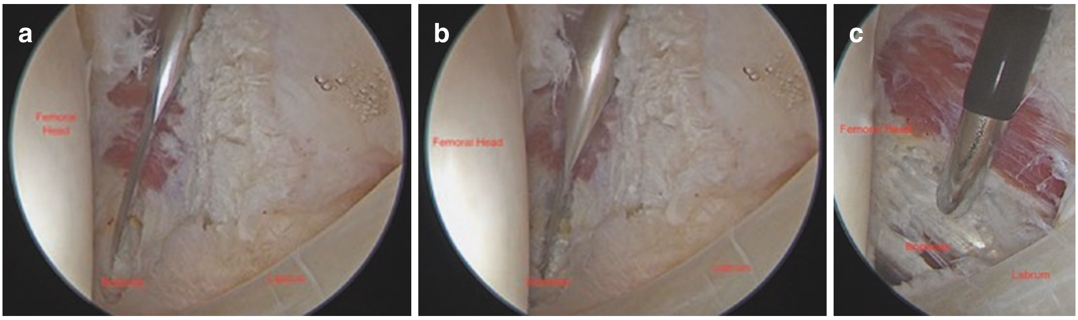

Fig. 25.3 Arthroscopic tenotomy via the central compartment at the level of the labrum

25.6.2 Complications and Postoperative Rehabilitation

Although fractional lengthening remains a successful procedure, there are complications associated with it. The most commonly reported are neurovascular injury [33–35], hip subluxation or dislocation [36], and intra-abdominal fluid extravasation [37, 38]. Rare complications such as heterotopic ossification or pseudoaneurysm of femoral circumflex artery have also been reported [39]. All of these are related to hip arthroscopy, which generally carries an overall rate of complications of 3.3% [40]. Late common manifestations are represented by muscle atrophy and decreased hip flexion strength, which can be regained with rehabilitation [41, 42].

Postoperative mobilization with crutches is initiated as soon as possible and weight-bearing allowed as tolerated. Active hip flexion-extension mobilization with the help of an exercise bike with zero resistance is commenced immediately after surgery. The patient commences a rehabilitation program with a physiotherapist with expertise in hip surgery on the ward and seen on a weekly basis for 6 weeks and then on a once in 2 weeks basis for a total of 16 weeks. Iliopsoas stretches form a major part of the rehabilitation programme.

Tips and Tricks

- Confirm iliopsoas impingement on ultrasound prior to instituting treatment
- Always commence with a physical therapy programme first in non-arthroplasty impingement as most patients will benefit from that programme
- Confirm iliopsoas hyperaemia and labral pathology intra-operatively
- Stop releasing the iliopsoas once you reach the muscle fibres of iliacus using the transcapsular approach to avoid any injury to the blood vessels
- Be aware of intra-abdominal extravasation, which is a serious complication following this procedure

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Proximal Hamstring Repair/ Reinsertion: Open Surgery Technique

26

Lasse Lempainen, Jussi Kosola, and Sakari Orava

26.1 Introduction

Hamstring injuries can occur in various sports activities, but are also common among regular people, for example, while falling down. These injuries can be highly disabling and they can lead to substantial time loss from sports [1]. Some of the hamstring injuries require surgical treatment for optimal recovery [2]. Various open surgery techniques have been presented in literature [3–9]. The goal of the proximal hamstring rupture repair is to restore the anatomy of the injured structures so that athlete's rapid recovery and safe return to sports is possible with the low rate of recurrent hamstring injuries. Without adequate treatment, proximal hamstring rupture can result in permanent loss of hamstring function and strength and also lead to chronic pain [1, 10].

26.2 Surgical Indications

Most hamstring injuries are strains and can be treated conservatively with good results. However, there are cases in which surgery should be considered already in the acute phase. Also, there are cases in which surgery should be considered later if non-operative treatment appears to be unsuccessful.

The physician uses clinical findings (posterior thigh hematoma, pain and decreased strength in hip extension/knee flexion) and MRI imaging to determine whether the athlete has complete (Figs 26.1 and 26.2) or incomplete proximal hamstring rupture (Figs. 26.3 and 26.4).

26.2.1 Absolute Indications for Surgery

In an athlete, a proximal one-tendon avulsion or rupture with a clear retraction should be treated surgically regardless of the hamstring tendon biceps femoris (BF), semimembranosus (SM) or semitendinosus (ST) (Figs. 26.3 and 26.4). If two or all three of the hamstring muscles are avulsed, surgery should be considered in all patients if there are not contraindications to surgery. Suture anchors are typically used to reattach the tendon to the ischial tuberosity.

Apophyseal avulsions of the ischial tuberosity occur occasionally in adolescent athletes [11]. Surgical repair is traditionally recommended if the avulsed fragment is displaced by more than 10–15 mm.

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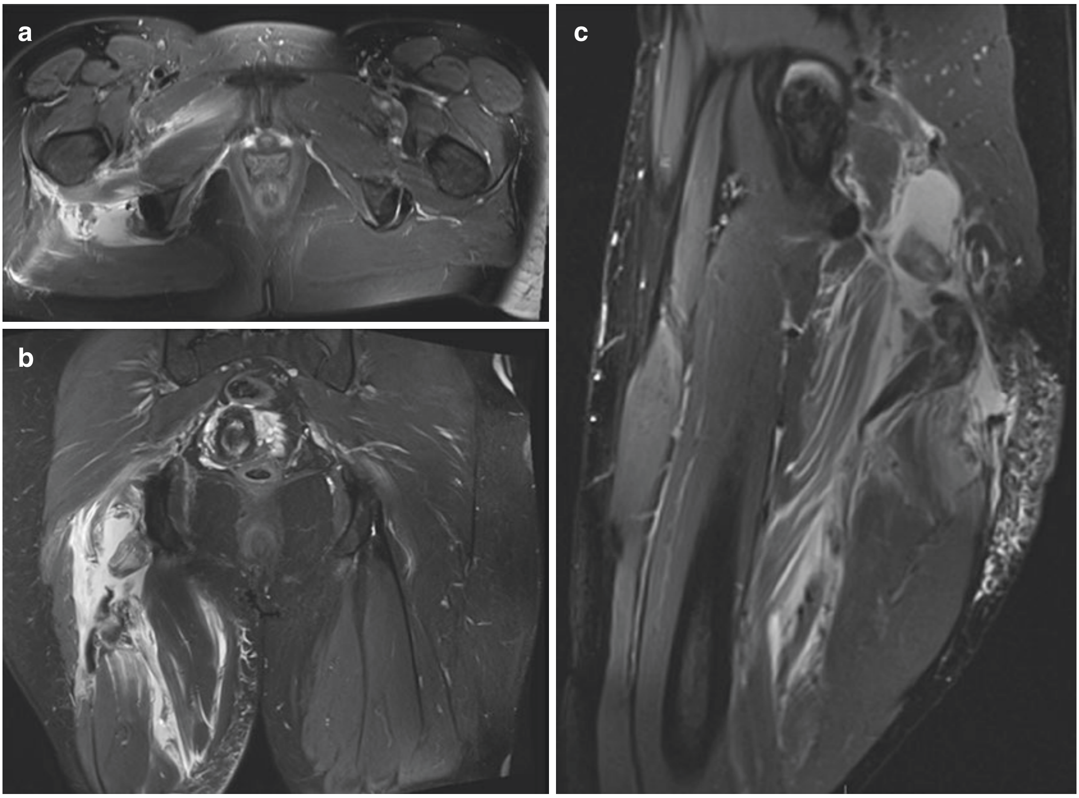

Fig. 26.1 Complete proximal three-tendon avulsion: (**a**) axial, (**b**) coronal and (**c**) sagittal planes

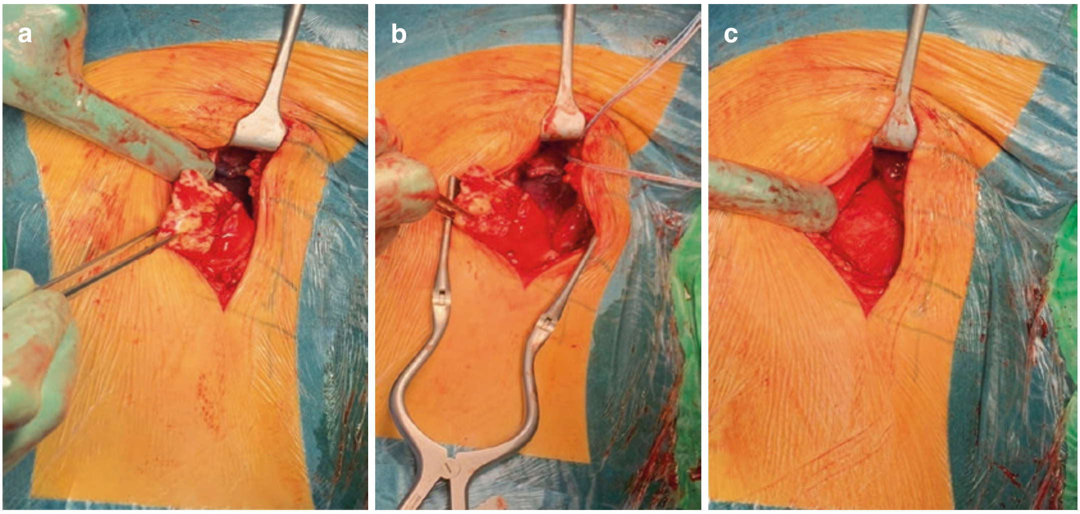

Fig. 26.2 Surgical approach and anatomy: (**a**) Retracted complete proximal three-tendon avulsion identified using vertical skin incision; (**b**) suture anchors placed anatomically to ischial tuberosity; and (**c**) prepared and suture-loaded tendons are secured to the footprint

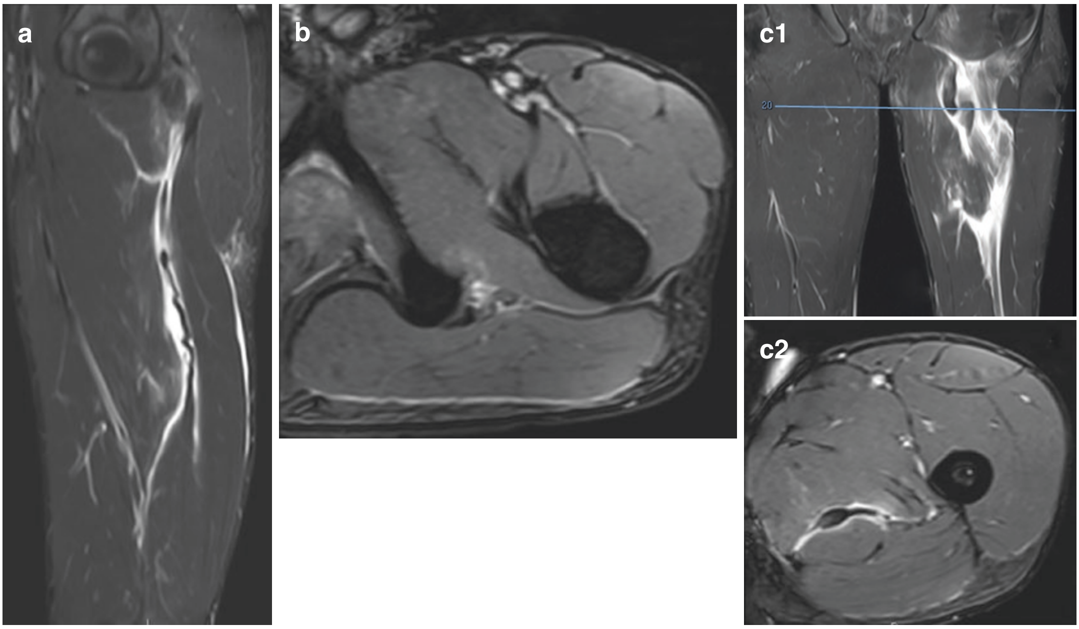

Fig. 26.3 Complete proximal one-tendon avulsion (semimembranosus): (**a**) sagittal, (**b**) axial, and (**c**) coronal (*1*) with subsequent axial view (*2*)

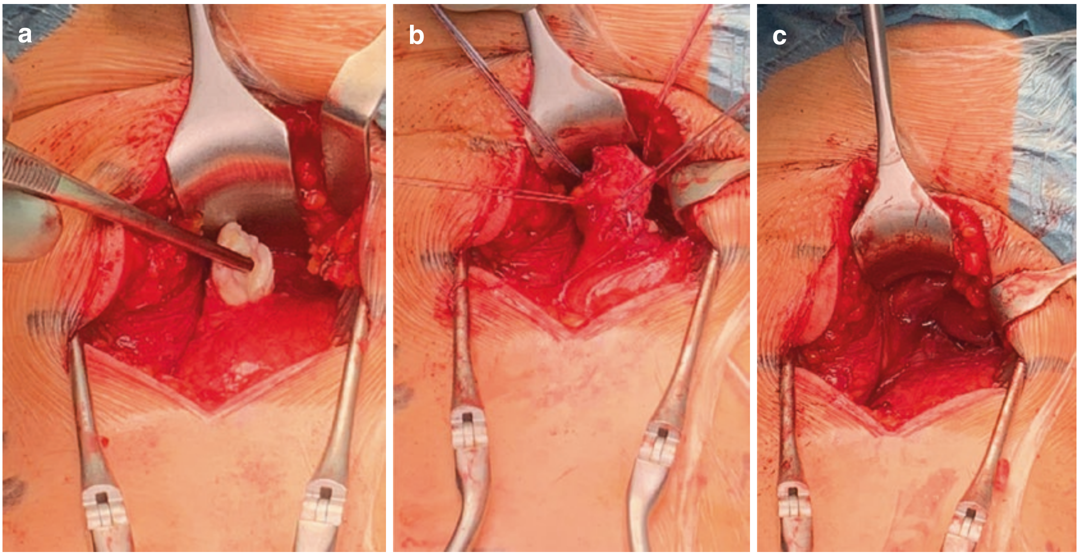

Fig. 26.4 (**a**) Retracted single tendon (biceps femoris) avulsion identified using vertical skin incision; (**b**) suture anchors placed anatomically to ischial tuberosity; and (**c**) prepared and suture-loaded tendon is secured to the footprint

26.2.2 Relative Indications for Surgery

Occasionally incomplete tears especially when recurrent form scar tissue and adhesions that cause persistent symptoms and are non-responsive to conservative treatment. This can occur in the proximal interface or in the proximal tendinous part or in the central tendon area. In proximal incomplete avulsions that remain symptomatic, the MRI may show liquid between the bone and the tendon which is a sign of incomplete healing. In those cases, surgery gives often a good result.

It has been suggested that paramuscular/central tendon injuries especially in the BF may have a higher risk of poor healing with conservative treatment [12]. Also, the risk of a recurrent injury may be high. In these injuries, there is often an incomplete tear of the paramuscular tendon typically in the area of 5–20 cm from the proximal origin. Often the muscle tissue is torn off from the tendon also. When a tear like this remains symptomatic after adequate conservative treatment or there are recurrences, surgery should be considered. Full continuity of the central tendon is restored with sutures and the attachment of the muscle to the tendon is reinforced. It is important to avoid overtightening of the repaired tendon. Scar tissue may be removed. Suture anchors may be used if the tear is located close to the bony origin.

In chronic proximal hamstring ruptures and in some re-rupture cases, anatomic apposition of the retracted muscles cannot always be achieved. In those cases, fascia lata autograft augmentation or for example, Achilles allograft have been used to connect the retracted hamstrings to ischial tuberosity [13, 14]. If patient has radiating nerve pain, sciatic nerve is typically adhered to the scar tissue and it should be freed for good outcome. It seems that late reconstruction of complete proximal hamstring avulsion with fascia lata autograft augmentation or allograft can result in enhancement of muscle strength, better function of the hamstrings and improved the leg control. Also symptoms derived from retracted hamstrings causing stretching to the sciatic nerve could be alleviated.

26.3 Surgical Technique

26.3.1 Patient Positioning and Preparation

In surgery, the patient is placed in the prone position and usually spinal anaesthesia is used. The ipsilateral knee is slightly flexed (20°) to relax the hamstring muscles. The whole area of the hamstrings should be prepared especially in more chronic cases.

A vertical skin incision should be used especially when there is retraction of the ruptured tendons as they may need to be mobilized to achieve tension-free contact to the ischial tuberosity again. The incision starts at the ischial tuberosity extending distally, approximately 10–15 cm. A fasciotomy is done to the common hamstring fascia and it is continued distally, approximately 15 cm from the origin of the hamstring muscles. The lower edge of the gluteus maximus muscle is freed and careful haemostasis should be performed. The posterior cutaneous femoral nerve should be identified and spared as well. This is not always easy, especially in the chronic cases. The ischial tuberosity is exposed by retracting superiorly the inferior border of the gluteus maximus muscle. The sciatic nerve can be found lateral to the ischial tuberosity and it should be freed from adhesions in chronic cases, especially if there are sciatica type of symptoms.

In acute ruptures, hematoma or seroma is often present. In more chronic ruptures, adhesions and scarring is covering the ruptured area. In chronic cases, ruptured structures should be carefully freed and mobilized like sciatic nerve.

26.3.2 Surgical Repair

In most cases, re-attachment of the torn tendons can be done using suture anchors. When surgery is performed in the early phase, anatomical reattachment can be done. In chronic cases, the torn tendons can be reattached slightly distal and medial to the original site of the ischial tuberosity to avoid over tightening the tendons.

Anchor placement to the ischial tuberosity should be anatomical and typically 2–3 suture anchors are used to reinsert ruptured tendons back to the bone. Suture passing through tendon should be done carefully and multiple times and then the ruptured tendon is reinserted to the footprint area by pulling the gliding strand of the suture anchor. Care must be taken not to rotate or misplace tendon heads. After the repaired proximal hamstring tendons are in good contact for prepared bony cortex surface, knots can be done.

If proximal part of the tendon or central tendon is ruptured, the goal of the repair is to restore full continuity of the tendon with sutures and also the attachment of the muscle to the tendon is reinforced. It is important to avoid over tightening of the repaired tendon. Scar tissue may be removed. Suture anchors may be used if the central tendon tear is located close to the bony origin.

Wound closing is done by layers; subcutaneous tissue and skin.

26.4 Post-operative Rehabilitation Protocol

- Complete proximal hamstring rupture (acute repair, no augmentation)
- Isolated proximal biceps femoris rupture/conjoint tendon (BF + ST) rupture
- Proximal semimembranosus rupture

General principles of rehabilitation and routine protocol:

- Often daily surgery; patient can leave the hospital same day.
- Post-operatively, no immobilization with casts or orthoses are needed.
- First knee slightly flexed while laying on bed.
- Wound check after 2–3 days, sutures removed after 10–12 days.
- Walking with help of two crutches during first 1–3 weeks. However, full-weight bearing is allowed immediately after operation while standing and slow walking.
- Calf and gluteus muscle activations can be started right after operation as well as isometric hamstring contractions.
- Sitting should be avoided as much as possible during first 3 weeks.
- Active stretching of the hamstrings should be avoided first 4 or 5 weeks.
- Functional strengthening or physiotherapy starts normally at 4 weeks. Gradually increasing load of the hamstrings. It is also important to concentrate on to the gluteus, calf muscles and pelvis core training.
- Light aqua training can be started after 3–4 weeks, cross-trainer or stationary biking after 6–8 weeks, Alter-G running after 8–10 weeks, normal running after 2–3 months and return to field after 2.5–4 months from the operation.
- Return to high level of sports after 3–5 months from the operation when pain-free and safe sports–related movements are successfully performed.

26.5 Complications

Severe complications are possible relating to the hamstring surgery. One should be aware and experienced about general principles of muscle tendon surgery. Some of these complications are related to the injury itself and some to the surgical technique.

There are some cases presented in the literature in which a complete proximal hamstring rupture has caused a dysfunction of the sciatic nerve with resulting complete foot drop and numbness of the lateral calf and dorsal foot [15, 16]. Similar cases have been described occurring after partial proximal hamstring tears [17, 18]. The damage to the intramuscular nerve branches of the hamstring muscles is also a possible complication and could be seen, for example, in chronic proximal avulsion injuries. Nerve branch lesions can be also result from the surgery. If denervation of the hamstring muscles is suspected before operation, electroneuromyography (ENMG) study is recommended.

Lesion of posterior femoral cutaneous nerve is also possible and that is especially related to the cases needing reoperation. Most of these patients have some numbness around the scar area, which do not cause any harm in their activities of normal daily life.

Post-operative infections are very rare in good planned and performed operations. We use antibiotic prophylaxis routinely before operation. After operation careful wound control(s) is of course important as well. Sutures should not be kept for too long time.

Good knowledge of the anatomy and 'experienced hands' are important and essential to avoid surgery-related failures. Hamstring operations are often demanding procedures and should be done by surgeons specialized for these injuries. One should be aware how to handle sciatic nerve, how to place and insert anchors to the ischial tuberosity and how to prepare tendons and take the suture attachments from the ruptured tendons.

26.6 Conclusion

In competitive athlete, open surgical treatment for proximal hamstring tears gives good outcome [19, 20]. Indications for operative and non-operative treatment depends on the activity level of the patient, the retraction of the avulsion and the number of avulsed tendon heads [2, 5, 10, 21, 22]. The vertical incision gives good visualization to the injured tendons and neural structures. By using modern suture anchors, safe and tissue friendly reattachments are possible; ruptured tendons can be pulled to the anatomic insertion securely which enables the strength of the hamstrings be restored. After uneventful operation the athlete can return to play within one competitive season if the rehabilitation is done by well-trained lower extremity specialized physiotherapist and staged rehabilitation program [12, 20].

Few tips/tricks

– Be aware of normal hamstring anatomy; tendon insertion sites and nerve structures.
– The location of posterior femoral cutaneous nerve can vary a lot.
– While doing reinsertion of the tendons avoid excessive tightness.
– Step by step rehabilitation is important to avoid recurrent injuries.

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27

Hamstring Repair/Reinsertion: Endoscopic Treatment Options

F. Bataillie, B. Favier, and N. van Beek

27.1 Pathology of Proximal Hamstring Ruptures

27.1.1 Acute Ruptures

Acute avulsions are commonly caused by an eccentric contraction of the hamstring when there is an acute hyperflexion of the hip combined with an extension of the knee. This is accompanied by an acute onset of pain in the posterior proximal thigh with extensive bruising and swelling in this area. Knee flexion is often compromised and sitting on the affected side is painful.

27.1.2 Chronic Ruptures

Chronic ruptures are often found in runners. Chronic proximal hamstring tendinosis and partial tearing of the proximal hamstring origin are known causes of chronic posterior hip and thigh pain. Partial tears often occur in the setting of degenerative tendinosis of various degrees and occur more frequently with older age.

On an MRI, the differentiation between acute and chronic tears can clearly be made as chronic tears show no intensity on T2-weighted imaging but fatty infiltration of the muscle belly.

27.2 Endoscopic Treatment

27.2.1 Patient Installation

The patient is installed in a prone position with the hip in 10° of flexion (Fig. 27.1). The operated leg is fully disinfected so that manipulation of both the hip and knee in extension, flexion as well as rotation can be safely performed during surgery. These movements may be necessary to relax the nerves and/or hamstring muscles.

27.2.2 Portal Placement

The placement of the different portals was extensively studied by the author through an anatomical cadaver study. The risk of harming vital structures was thoroughly investigated.

There are four possible portals to access the deep gluteal compartment in the prone position. The anatomical references for placing the different portals are all in line with the body axis and

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Fig. 27.1 Patient position for endoscopic treatment of the posterior compartment. The patient is placed in a prone position with the hip at 10° flexion

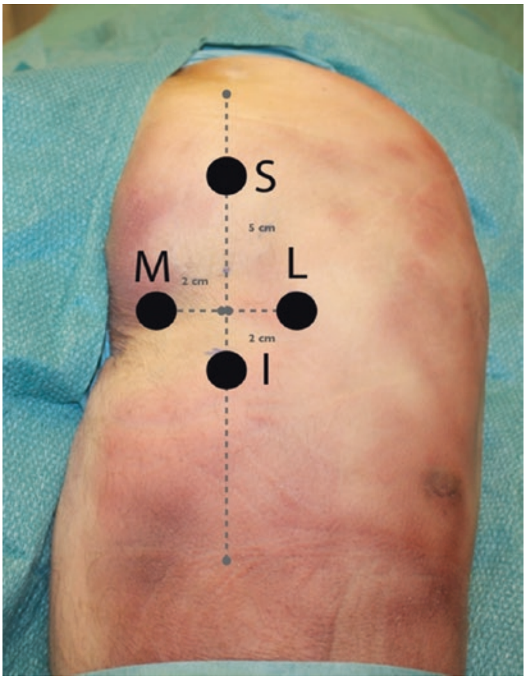

Fig. 27.2 Endoscopic portal placement in the posterior compartment. *S* superior portal, *L* lateral portal, *I* inferior portal, *M* medial portal

consist of a vertical line through the centre of the sciatic tubercle and a horizontal line located along the inferior palpable border of the sciatic tubercle.

The primary portal is the inferior portal and is located on a vertical line approximately 2 cm under the horizontal line (Fig. 27.2). When making this portal it is important to aim every instrument towards the sciatic tubercle and to use blunt dissection to release the large amounts of fibrous strands between the skin and the sciatic tubercle. The inferior portal is the main portal for visualisation.

The medial portal is located on the horizontal line approximately 2 cm medial from the vertical line (Fig. 27.2). Blunt and cautious dissection when creating this portal towards the tubercle is essential to release the fibrous strands.

The lateral portal is also placed on the horizontal line at approximately 2 cm from the vertical line, which is opposite to the medial portal. This portal runs straight over the sciatic nerve and the posterior femoral cutaneous nerve. It is thus important to create this portal under direct endoscopic visualisation through the inferior portal. The lateral portal is a portal which mainly functions as an access portal for the different instruments to palpate or release muscles and nerves. Anchors for placement in the tubercle should be best placed laterally through this portal.

If necessary, a superior portal can be added. This portal is positioned on the vertical line at 5 cm above the horizontal line. This portal is safe to use as long as instruments are aimed at the sciatic tubercle. This portal can be used when hamstring repairs are needed more proximally.

27.2.3 Anatomical Dissection

Posteriorly, the deep gluteal area is completely covered by the gluteus maximus muscle and runs from its inferior border to the inferior gluteal nerve. Endoscopic visualisation and the related working field is limited to this area. Visualisation may be extended more proximally, yet the inferior border of the piriformis muscle marks the absolute limit. Medially there is a good visualisation possible of the sciatic tubercle with the insertion of the semimembranosus muscle, as well as the conjoined tendon of the biceps femoris and semitendinosus muscle. There is also easy access to the split between the two insertions. The semimembranosus muscle is mainly located on the upper lateral border of the sciatic tubercle.

The anterior border is defined by the quadratus femoris muscle and the other external rotators. These muscles can sometimes be traced back to their insertion on the femur.

The distal border is located approximately 6 cm below the sciatic tubercle where the muscular nerve branch of the sciatic nerve innervates the semimembranosus muscle.

The most important nerves that can be visualised are the sciatic nerve and the posterior femoral cutaneous nerve. These nerves should therefore always be visualised at the initiation of the endoscopy, so they can be carefully isolated from the surrounding soft tissues.

27.2.4 Hamstring Repair

A second pathology that can be treated through endoscopy is ischial bursitis or the partial hamstring rupture. The procedure consists of a sciatic nerve release, followed by localisation of the ischial bursitis and finalised by placing at least two anchors in the sciatic tubercle to reattach the harmed hamstring to, most commonly, the semimembranosus muscle. Before placing the anchors, we do a selective debridement of the soft tissue covering the ischial tuberosity. The anchors are inserted from lateral to medial using the split between the semimembranosus and the conjoined tendon of biceps femoris and semitendinosus. The fibre wires are retrieved through the damaged muscles and the knots are placed inferior and lateral of the ischial tuberosity. All this must be done under endoscopical control of the sciatic nerve (Fig. 27.3).

A full thickness tear of the hamstring muscles can theoretically be endoscopically reattached, yet because of the technical complexity to reattach the conjoint tendon and the semimembranosus muscle with sufficient number of anchors and without damaging the neural structures, the author prefers open surgery when addressing proximal full hamstring repair.

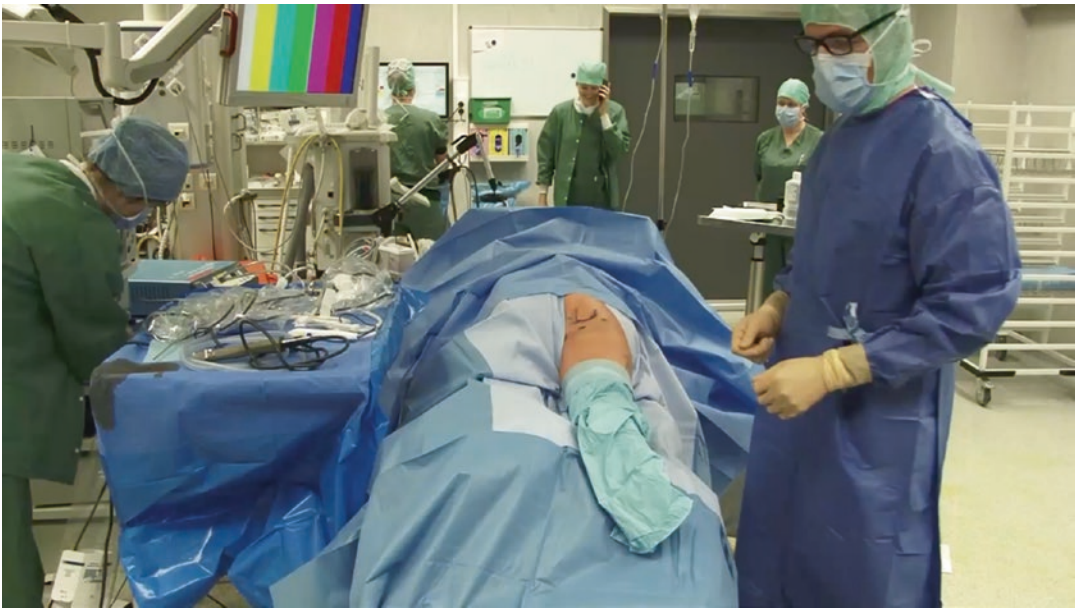

Fig. 27.3 Sciatic nerve release and endoscopic suturing of the semimembranosus muscle

A possible fourth pathology that can be treated endoscopically is ischiofemoral impingement. In this case, both a release of the femoral quadratus muscle at the level of the sciatic tubercle or a resection of the lesser trochanter is possible.

Tips and Tricks

(a) The release of the sciatic nerve and the posterior femoral cutaneous nerve is the start of the operation and must be complete before addressing the hamstrings.
(b) Use radiofrequency probe for blunt dissection, and use the coagulation only to control bleeding
(c) Use small scissors of laparoscopic surgery in case of difficult dissection.
(d) Use non resorbable anchors with fibre wire or fibre tape for suturing the hamstrings
(e) Endoscopic sciatic nerve control after every endoscopic work: release, sutures
(f) Physiotherapy with sciatic nerve mobilisation starting day 1
(g) Do not push the rehabilitation.

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Part VI

Nerve Disorders

Sciatic Nerve Release/Piriformis Tenotomy: Endoscopic Surgery

28

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28.1 Etiology

Multiple orthopedic and non-orthopedic conditions may manifest as a DGS [1–3]. Although deep gluteal syndrome (DGS) and piriformis syndrome were considered synonymous in the past, it has since become clear that piriformis syndrome is just one of many different causes that may be responsible for sciatic nerve entrapment causing pain in the buttock. In fact, in only one-fourth of the patients in a systematic review was the piriformis found to be causing entrapment of the sciatic nerve intraoperatively [4]. The sciatic nerve can also be affected in locations above and below the deep gluteal space, as in intra-pelvic vascular and gynecologic abnormalities. The concept of fibrous bands, which may or not contain blood vessels, playing a role in causing symptoms related to sciatic nerve entrapment represents a radical change in the current diagnosis and therapeutic approach for the all-inclusively used term “piriformis syndrome” [5, 6]. We will focus in this chapter in the endoscopic treatment of fibrous bands and piriformis compression of the sciatic nerve.

28.1.1 Fibrous and Fibrovascular Bands

Typically constricting fibrous bands are present in many cases of sciatic nerve entrapment during endoscopy [1, 7]. Under normal conditions, the sciatic nerve is able to stretch and glide in order to accommodate moderate strain or compression associated with joint movement [8]. Diminished or absent sciatic mobility during hip and knee movements due to these bands is the precipitating cause of sciatic neuropathy (ischemic neuropathy) [9] (Fig. 28.1). From the point of view of its macroscopic structure, there are three primary types of bands: fibrovascular bands, with vessels macroscopically identifiable by magnetic resonance imaging and endoscopy, pure fibrous bands, without identifiable macroscopic vessels, and pure vascular bands, exclusively formed by a vessel without surrounding fibrous tissue [5, 6]. Based on their location, they can be classified as

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proximal, which affect the sciatic nerve in the vicinity of the greater sciatic notch, distal, which affect it in the ischial tunnel region between the quadratus femoris and proximal insertion of the hamstrings, and middle bands, located at the level of the piriformis and obturator internus-gemelli complex. In each of these three locations, these bands can be located medial or lateral to the sciatic nerve. Depending on the pathogenic mechanism, bands can be classified as follows.

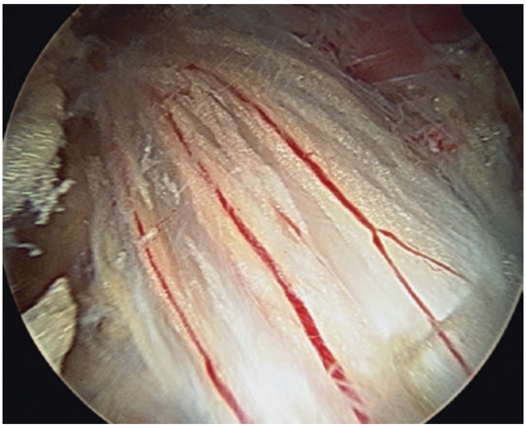

Fig. 28.1 Sciatic nerve vascularity. Normal sciatic nerve will have noticeable epineural blood flow and epineural fat, whereas an abnormal sciatic nerve will appear white, lacking epineural blood flow

(a) *Compressive or bridge-type bands (type 1),* which limit the movement compressing the nerve from anterior to posterior (type 1A) or from posterior to anterior (type 1B). The former is located in front of the sciatic nerve. These fibrous bands usually extend from the posterior border of the greater trochanter and surrounding soft tissues (distal insertions are variable) to the gluteus maximus onto the sciatic nerve and extend up to the greater sciatic notch (Figs. 28.2, 28.3, and 28.4; Video 28.1).

(b) *Adhesive bands or horse-strap bands (type 2)*, which bind strongly to the sciatic nerve structure, anchoring it in a single direction and not allowing it to perform its normal excursion during hip movements. These bands can be attached to the sciatic nerve laterally from the major trochanter (type 2A) or medially from the sacrotuberous ligament (type 2B). Lateral bands are the most common. Among those classified as medial bands, a proximal location is more frequent (Fig. 28.5; Videos 28.2 and 28.3).

(c) *Bands anchored to the sciatic nerve with undefined distribution (type 3).* These kinds of bands with an erratic distribution are characterized by anchoring the nerve in multiple directions (Fig. 28.6; Video 28.4)

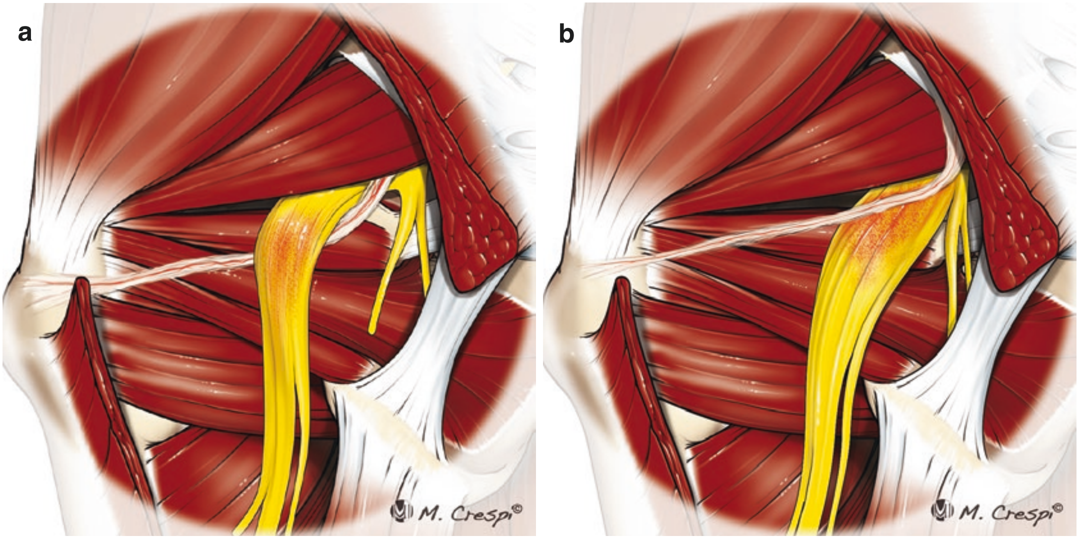

Fig. 28.2 (**a**, **b**) Compressive or bridge-type bands limiting the movement of the sciatic nerve from anterior to posterior (type 1A) (**a**) or from posterior to anterior (type 1B) (**b**). (Reprint with permission from [5])

Fig. 28.3 Left hip. Endoscopy shows the sciatic nerve compression by a proximal fibrovascular band. Note the bleeding vessel during resection of the band

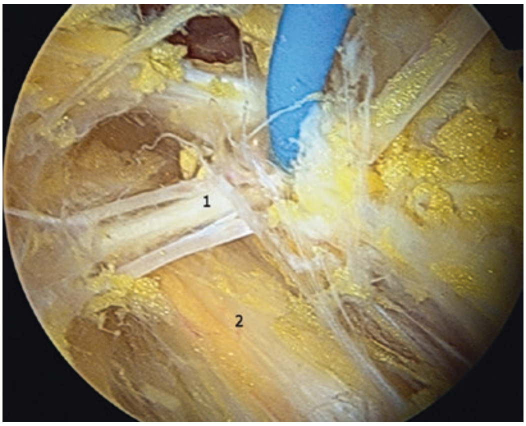

Fig. 28.4 Right hip: Sciatic nerve compression by a proximal fibrovascular band. (1) Fibrotic band between two vascular bands. (2) Sciatic nerve

28.1.2 Piriformis Syndrome

Piriformis syndrome can be classified as a subgroup of DGS but not all DGSs are piriformis syndrome. The potential sources of pathology related to the piriformis muscle include:

28.1.2.1 Hypertrophy of the Piriformis Muscle

- Asymmetrically enlarged piriformis muscle with anterior displacement of the sciatic nerve may be a cause of DGS. Asymmetry associated with sciatic nerve hyperintensity at the sciatic notch revealed a specificity of 93% and sensitivity of 64% in patients with piriformis syndrome distinct from that which had no similar symptoms [10].

28.1.2.2 Dynamic Sciatic Nerve Entrapment by the Piriformis Muscle

- Dynamic entrapment of the sciatic nerve by the piriformis is not uncommon [7]. Often the only finding at imaging that can be shown is nerve signal hyperintensity in edema-sensitive sequences. The definitive diagnosis is endoscopic, demonstrating the entrapment during dynamic maneuvers.

28.1.2.3 Anomalous Course of the Sciatic Nerve (Anatomical Variations)

- Descriptions of variations concerning the relationship between the piriformis muscle and sciatic nerve have been limited [8, 11–13]. Six categories of anatomic variations of the relationship between the piriformis muscle and sciatic nerve were originally reported in 1938 by Beaton and Anson [6]. Smoll presented the overall reported incidence of these six variations in over 6000 dissected limbs. (A) Sciatic nerve passes below the piriformis muscle; (B) Divided nerve passes through and below the muscle; (C) Divided nerve passes through and above the muscle; (D) a divided nerve passes above and below the muscle; (E) Undivided nerve passes through the piriformis; or (F) Undivided nerve passes above the

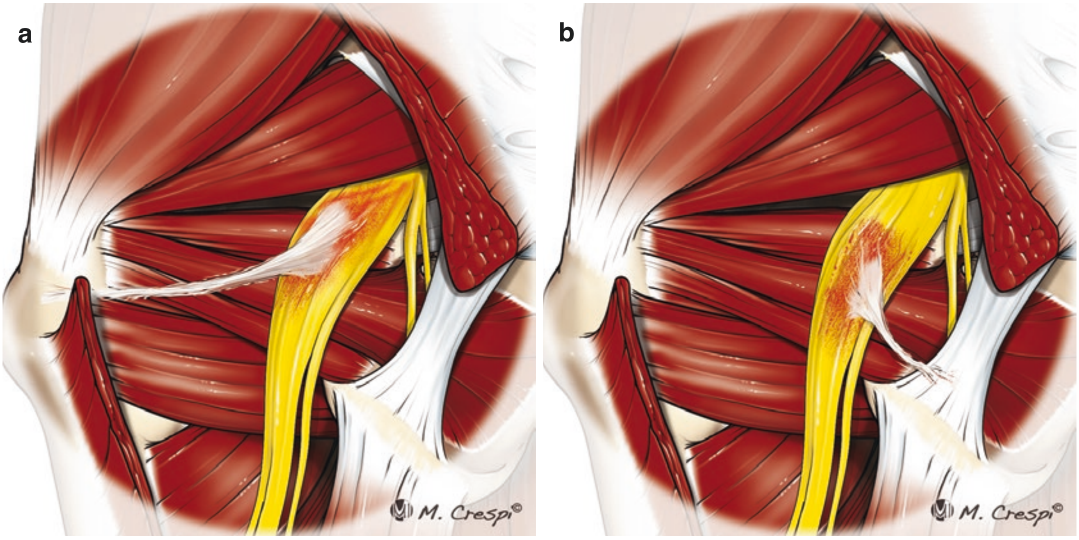

Fig. 28.5 (**a**, **b**) Adhesive or horse-strap bands (type 2), which bind strongly to the sciatic nerve structure, anchoring it in a single direction. They can be attached to the sciatic nerve laterally (type 2A) (**a**) or medially (type 2B) (**b**). (Reprint with permission from [5])

Fig. 28.6 Left hip: Bands anchored to the sciatic nerve with undefined distribution (type 3)

muscle (Fig. 28.7). Relationships A, B, C, D, E, and F occurred in 83.1%, 13.7%, 1.3%, 0.5%, 0.08%, and 0.08% of limbs, respectively [12]. Therefore, with the exception of relationship A (normal course), the B-type piriformis-sciatic variation is the most commonly found. The anomaly itself may not always be the etiology of DGS symptoms as some asymptomatic patients present these variations and some symptomatic patients do not.

A subsequent event such as any etiology reported in this article or prolonged sitting, direct trauma to the gluteal region, prolonged stretching, overuse, pelvic/spinal instability or orthopedic conditions may then precipitate sciatic nerve neuropathy. Pecina [14] found that the undivided nerve passed below the muscle in 78% of his dissections and the divided nerve passed through and below the muscle in 21%.

28.2 Clinical Examination and Symptoms

A comprehensive history and physical examination can orientate the specific site where the sciatic nerve is entrapped, as well as several radiological signs that support the suspected diagnosis. Clinical assessment of patients with DGS is difficult since the symptoms are imprecise and may be confused with other lumbar and intra- or extraarticular hip diseases. It is usually characterized by a set of symptoms and semiological data occurring in isolation or in combination [1, 7, 15]. The most common symptoms include hip or buttock pain and tenderness in the

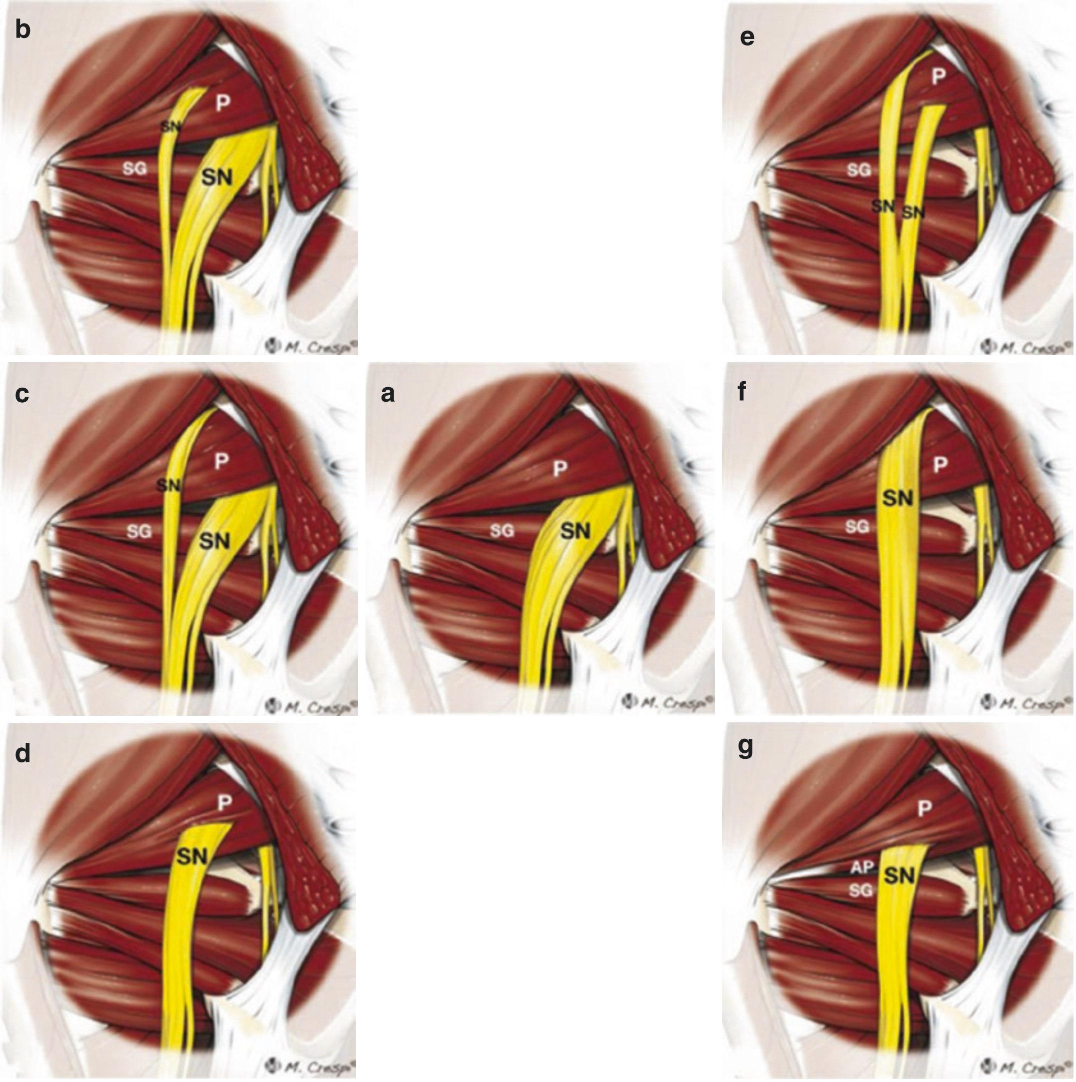

Fig. 28.7 Anatomic variations of the relationship between the piriformis muscle and sciatic nerve. (**a–f**) Diagrams illustrate the six variants, originally described by Beaton and Anson. (**a**) An undivided nerve comes out below the piriformis muscle (normal course). (**b**) A divided sciatic nerve passing through and below the piriformis muscle. (**c**) A divided nerve passing above and below an undivided muscle. (**d**) An undivided sciatic nerve passing through the piriformis muscle. (**e**) A divided nerve passing through and above the muscle heads. (**f**) An undivided sciatic nerve passing above an undivided muscle. (**g**) Diagram showing an unreported additional B-type variation consisting of a smaller accessory piriformis (AP) with its own separate tendon. *SN* sciatic nerve, *P* piriformis muscle, *SG* superior gemellus muscle. (Reprint with permission from [5])

gluteal and retro-trochanteric region and sciatica-like pain, often unilateral but sometimes bilateral, exacerbated with rotation of the hip in flexion and knee extension. Intolerance of sitting more than 20–30 min, limping, disturbed or loss of sensation in the affected extremity, lumbago and pain at night getting better during the day are other symptoms reported by patients. An antalgic position is frequently found. Physical examination tests have been used for the clinical diagnosis of sciatic nerve entrapment including the Lasègue test, Pace's sign, Freiberg's sign, Beatty test, FAIR test and seated piriformis stretch test. The active piriformis and seated piriformis stretch tests reveal higher sensitivity and specificity for the diagnosis of sciatic nerve entrapments than the other tests, especially when both are used in combination [15].

28.3 Medical imaging

Patients presenting with unexplained buttock pain must be initially screened with lumbar and pelvic imaging to rule out spinal pathology and/or unusual pelvic masses. Imaging plays a key role in the workup of unexplained hip pain. Plain radiography, ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) have all been used to assess posterior hip anatomy and pathologies [16]. Nerve stiffness associated with limb movements in the diagnosis of sciatic nerve entrapment in DGS can give us crucial information about the degree of nerve entrapment. Ultrasound strain elastography images are currently the only diagnostic procedure that is based on the assessment of nerve stiffness. In DGS the specificity of this method is 93.5% with sensitivity of 88.9%, and accuracy of 90.6% [17].

28.4 Conservative Treatment

The nonoperative treatment for DGS begins addressing the suspected site of entrapment. Compression from a hypertrophied, contracted, or inflamed muscle (piriformis, quadratus femoris, obturator internus, superior/inferior gemellus) is initially treated with rest, anti-inflammatories, muscle relaxants, and physical therapy. Guided injections of anesthetic or corticosteroid into the piriformis muscle can provide pain relief in patients not responding to physical therapy. It is important to administer the injection to the correct site, and different techniques can be utilized for guidance including fluoroscopy, CT, ultrasound, electromyography, and MRI. A trial of three injections has been recommended before opting for more aggressive therapy, taken on a case by case basis [16, 18, 19].

28.5 Operative Treatment

As a general guideline, only patients who have failed conservative measures are considered for operative treatment. The type of surgical procedure (open or endoscopic) depends on the clinical and imaging diagnosis. The response to targeted injections is helpful to predict the treatment success.

28.5.1 Endoscopic surgical technique

28.5.1.1 Indications

- Entrapment injuries of the sciatic nerve from its exit through the greater sciatic notch until the level of the quadratus femoris.

28.5.1.2 Anatomy

- The whole sciatic nerve trajectory in the deep gluteal space can be addressed by an endoscopic surgical technique, allowing the treatment of the diverse causes of sciatic nerve entrapment. (Video 28.5)
- Careful preoperative planning, precise portal placement, a knowledge of the anatomy and potential complications, and a methodical sequence of endoscopic examination, are essential for effective arthroscopy/endoscopy of any joint or space [20]. The technique of endoscopic decompression of the sciatic nerve requires significant hip arthroscopy experience with familiarity with the gross and endoscopic anatomy of the subgluteal space [21]. This space is a recently defined anatomic region for endoscopic access and is the cellular and fatty tissue located between the middle and deep gluteal aponeurosis layers [1, 7]. This space is anterior and beneath the gluteus maximus and posterior to the posterior border of the femoral neck, with the linea aspera (lateral), the sacrotuberous and falciform fascia (medial), the inferior margin of the sciatic notch (superior), and the hamstring origin (inferior). Within the deep gluteal space there are ligamentous, muscular, neurological, and vascular structures of great importance.

28.5.1.3 Patient's Position

- Supine position in a traction table, standard preparation for hip arthroscopy, no traction, and 20° of contralateral tilt.
- May be performed concomitant to a hip arthroscopy of the central and/or peripheral compartments, if indicated. To help avoid post-surgical stretch injury, it is recommended that intraarticular work be performed separately from extra-articular work.
- Leg is abducted to about 15–20° in order to open the interval between the trochanter and the iliotibial band and the leg is internally rotated 20–40°, for the same reason (Fig. 28.8).
- Alternative methods: This procedure can also be done in the lateral decubitus position [22, 23].

28.5.1.4 Instruments/Equipment/Implants Required

- Arthroscopic shaver or dissection scissors.
- Seventy degree arthroscope, and in some cases or larger patients the use of an extra-longer arthroscope is required.
- Radiofrequency probe. The cannulas are opened to maintain the fluid flow, when utilizing the radiofrequency probe. Additionally, the temperature profile during activation of a monopolar radiofrequency device was found to be safe at a distance of 3–10 mm to the sciatic nerve during activation times of 3, 5, and 10 s [24]. The standard approach to vessel cauterization is a 3 s interval of radiofrequency activation, maintaining continuous irrigation.
- Fluoroscopy. Frequent use of intra-operative fluoroscopy will confirm the proper location of the endoscopic view.

28.5.1.5 Portals

The subgluteal space is the posterior extension of the peritrochanteric space so entrance into this space is accomplished by portals traveling through the peritrochanteric space, which is between the greater trochanter and the iliotibial band. Different portals have been described to access the peritrochanteric space. Basically, we can divide these portals into two groups: (1) standard portals redirected to the peritrochanteric space (anterolateral, anterior, and posterolateral portals) and (2) portals described to access the peritrochanteric space [25] (proximal anterolateral accessory portal, distal anterolateral accessory portal, peritrochanteric space portal, and auxiliary posterolateral portal).

Fig. 28.8 Patient's Position: Supine position in a traction table, standard preparation for hip arthroscopy, no traction and 20° of contralateral tilt. Leg is abducted to about 15–20° in order to open the interval between the trochanter and the iliotibial band and the leg is internally rotated 20–40°, for the same reason

The peritrochanteric space portal is established at the level of the modified mid-anterior portal 1-cm lateral to the anterior superior iliac spine and in the interval between the tensor fascia lata (laterally) and the sartorius (medially). This portal enters peritrochanteric space underneath IT band at level of vastus lateralis ridge. Entering at vastus lateralis ridge avoids inadvertent deep penetration of vastus lateralis or gluteus medius muscle. The proximal anterolateral accessory portal is placed directly posterior to the proximal mid-anterior portal 3–4 cm proximal. It perforates the junction of the gluteus maximus and tensor fascia lata to form the iliotibial band, entering into the peritrochanteric space. The distal anterolateral accessory portal is placed distally to the peritrochanteric space portal at the same distance that exists between the first two portals (proximal anterolateral accessory and peritrochanteric space portals) (Figs. 28.9, 28.10, and 28.11).

28.5.1.6 Technique

Approach to Peritrochanteric Space

- First the peritrochanteric space portal is established. A 5.0-mm metallic cannula is positioned between the ITB (Ileotibial band) and the lateral aspect of the greater trochanter, and the tip of the cannula can be used to sweep proximal and distal to ensure placement in the proper location. Fluoroscopy can also be used to confirm that the cannula is located immediately adjacent to the greater trochanter at the vastus ridge (Video 28.6).

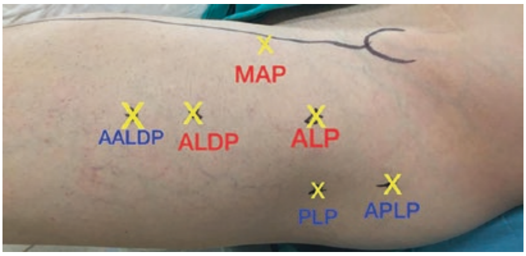

Fig. 28.9 Left gluteal region showing portal placement for subgluteal endoscopy. *MAP* midanterior portal, *AALDP* accessory anterolateral distal portal, *ALDP* anterolateral distal portal, *ALP* anterolateral portal, *PLP* posterolateral portal, *APLP* auxiliary posterolateral portal

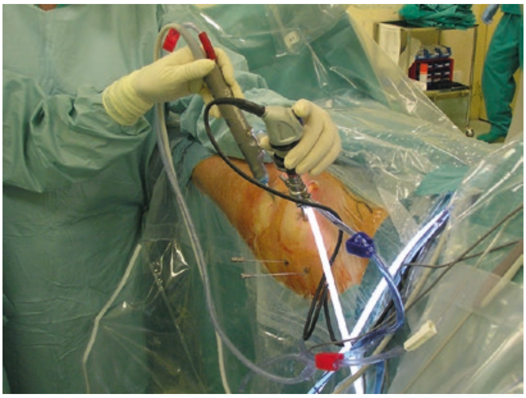

Fig. 28.10 Left gluteal region showing portal placement for subgluteal endoscopy. Needels in the posterolateral portal and auxiliary posterolateral portal

Fig. 28.11 Right hip: Scope in the anterolateral portal and shaver in the posterolateral portal

Orientation

- The arthroscope is place perpendicular to the patient and look in a distal direction in order to identify the gluteus maximus tendon inserting into the linea aspera of the femur posteriorly.

Procedure: Step-by-Step Description of the Technique

- Then the peritrochanteric space is entered through the anterolateral accessory, distal anterolateral accessory and posterolateral portals as working portals, and systematic inspection of this space is performed.
- Visualizing through the peritrochanteric portal, the examination begins at the gluteus maximus insertion at the linea aspera. Fibrous tissue bands may need to be removed from the space in this location to visualize the coalescence.
- Once this structure is identified, the area of the sciatic nerve can then be known. It lies directly posterior to this structure as it exits the subgluteal space. Rotating proximally, the vastus lateralis fibers are identified and can be traced toward its insertion on the vastus tubercle. Rotating the arthroscope anterior and superior, the gluteus minimus tendon is visualized anteriorly. Moving anteriorly above the gluteus

minimus lies the gluteus medius tendon and its attachment to the greater trochanter. (Video 28.7)

- Fibrous bands from the trochanteric bursa may need to be removed in order to best visualize the medius attachment to the greater trochanter.
- The ileotibial band sits posteriorly and can be seen with a small posterior maneuver of the arthroscope and rotation.
- For better sciatic nerve assessment, we switch the scope to the anterolateral portal and the procedure then continues by exposure of the bursa and resection of abnormal bursal tissue, and the sciatic nerve is identified. It lies 3–6 cm directly posterior to gluteus maximus tendon inserting into the linea aspera as it exits the subgluteal space.
- Sciatic nerve assessment is carry out through the anterolateral and posterolateral portals in many cases, but sometimes we need and auxiliary posterolateral portal [1]. It is placed 3 cm posterior and 3 cm superior to the greater trochanter. It allows a better visualization of the sciatic nerve up to the sciatic notch.
- Inspection of the sciatic nerve begins distal to the quadratus femoris, just above the gluteal sling. Visualize the sciatic nerve as it courses posterior to the quadratus femoris, noting the color, epineural blood flow, and epineural fat. A normal sciatic nerve will have noticeable epineural blood flow and epineural fat, whereas an abnormal sciatic nerve will appear white, lacking epineural blood flow. The epineural fat in many cases is diminished or completely obliterated. Take care to preserve as much of the epineural fat pad as possible during dissection [26].
- A blunt probe or surgical dissector can then be employed to expose the sciatic nerve and determine the tension [27] (Videos 28.8 and 28.9).
- After the dissection at the level of the quadratus femoris, turn the scope distal and perform all distal decompression before any proximal work. Inspect the ischial tunnel hamstring origin, and sacrotuberous ligament, releasing any fibers from the sciatic nerve. Assess the lateral, medial, and retrosciatic borders of the sciatic nerve to ensure the distal release is complete and identify the posterior cutaneous nerve.
- After the distal dissection, move proximal for a trochanteric bursectomy, while paying attention to keep the shaver blade directed away from the gluteus medius. The sciatic nerve should now also be possible to visualize proximally and care must be taken to avoid nerve damage caused by the motorized instrument or excessive traction. When the piriformis tendon is identified, it should be possible to identify the tendons of the gemellus and obturator internus muscles. Clean any vascular scar bands over the quadratus femoris and the conjoint tendon of the gemelli and obturator internus.
- A blunt dissector, such as a switching stick, can be employed for release of scar bands. Fibrovascular tissue can also be cauterized with a radiofrequency probe (Video 28.10).
- Finally, the piriformis muscle is located, and any abnormal anatomical variants are identified. Constant attention must be paid to the branches of the inferior gluteal artery lying in proximity to the piriformis muscle. Looking back proximal, in the region of the obturator internus a superficial arterial branch of the inferior gluteal artery crosses the sciatic nerve laterally between the piriformis and superior gemellus muscles and must be cauterized and released prior to inspection of the piriformis with a radiofrequency probe. Some cases involve a large vessel or a confluence of vessels which may require ligation. The piriformis muscle can be classified as: split, bulging split with the sciatic nerve passing through the body, split tendon with an anterior and posterior component, split in two distinct components with one dorsally and one inferiorly going between a bifurcated sciatic nerve [1].
- In many cases, a thick tendon can hide under the belly of the piriformis overlying the nerve. A rotatory shaver can be used to shave the distal border of the piriformis muscle to gain adequate access to the piriformis tendon (Fig. 28.12a, b).

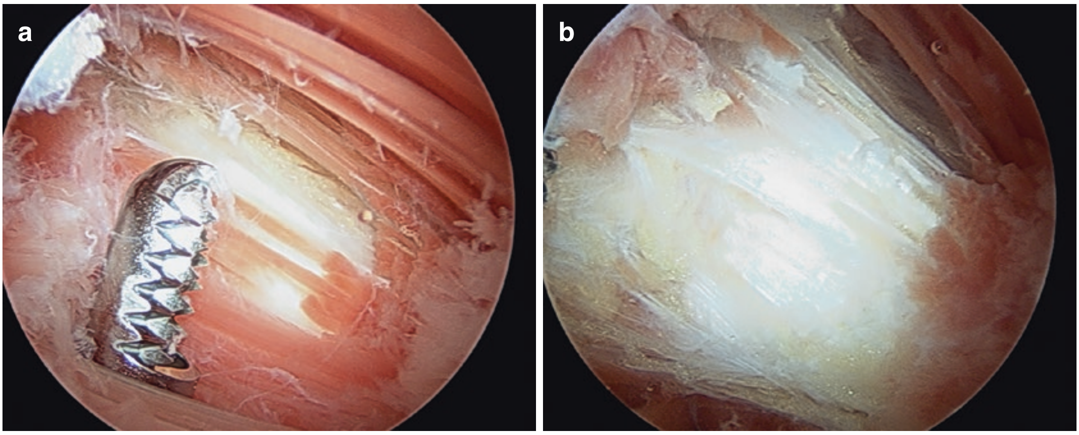

Fig. 28.12 Right hip: A thick tendon can hide under the belly of the piriformis overlying the nerve. A rotatory shaver can be used to shave the distal border of the piriformis muscle to gain adequate access to the piriformis tendon (**a**, **b**)

- Carefully grasp the tendon with arthroscopic scissors and pull the scissors toward you to ensure only the tendon is released (Video 28.11).
- A radiofrequency probe can also be used to release the tendon with a 3 s interval of activation, maintaining continuous irrigation (Video 28.12).
- Identify possible anatomical variations of the sciatic nerve above all the type 2 of Beaton (Video 28.13).
- Check obturator internus for anatomical variations and release if you consider there is compression of the sciatic nerve (Video 28.14). Finally probe the sciatic nerve up to the sciatic notch.
- With the arthroscope visualizing the nerve, the hip can be flexed and rotated in any direction in order to assess not only the mobility but also for any evident of impingement. The kinematic excursion of the sciatic nerve is then assessed with the leg in flexion with internal/external rotation and full extension with internal/external rotation (Video 28.15).

Postoperative Care and Rehabilitation

- The purpose of rehabilitation is to gain mobility and maintain movement of the hip joint and avoid any type of stretching of the nerve that can produce neuralgia or neuropraxy. The complete rehabilitation process takes an average of 24 weeks to return to previous activity [28]. The degree of excursion permitted by the sciatic nerve is affected by the position of the hip as well as the knee. The sciatic nerve tends to slide along the posterior border of the greater trochanter with the hip in a flexed, abducted, and externally rotated position [29]. Passive hip circumduction's beginning 45 degrees of hip flexion, maximum external rotation engaging the greater trochanter against the ischium to mobilize the sciatic nerve lateral with knee flexion can begin on day 1. Piriformis stretch and nerve glides can be applied under the limit of pain. Standard physical therapy protocol can begin as early as 6 weeks.

28.6 Avoiding Pitfalls and Complications

- Complications have involved hematomas brought on by early post-operative use of NSAIDs with excessive post-operative activity. We use tranexamic acid with the same protocol as in hip and knee arthroplasty to prevent this complication and the use of postoperative drain 18 h to control a possible bleeding.

- The most obvious issue is damage to the sciatic nerve. The role of devascularization of the nerve following surgical dissection needs to be evaluated and parameters need to be established [1].
- Scar formation around the nerve can be control with anti-adhesions gels in order to prevent painful scar neuropathy.
- Another area that deserves special mention is abdominal (retroperitoneal) fluid extravasation. This is monitored by maintaining fluid inflow at a minimum pressure that allows. Good visualization, along with the use of hypotensive anesthesia, when not clinically contraindicated. Other safeguards include the regular monitoring of the patient for any obvious signs of fluid distension as well as the continued awareness of any decrease in body temperature while being monitored by the anesthesia team [30].

28.7 Results

- Overall, 30 studies evaluating the surgical management (Open and endoscopic) of DGS were identified in the literature [4, 31, 32]. Although most of the studies identified were case series and reports, the results consistently showed improvement in pain and a low incidence of complications, particularly for endoscopic procedures. Outcomes were positive, with an improvement in pain at final follow-up. The incidence of complications from these procedures was low: Fewer than 1% and 8% of open surgical procedures and 0% and fewer than 1% of endoscopic procedures resulted in major (deep wound infection) and minor complications, respectively.
- We have reviewed and evaluated our results and endoscopic findings of 52 patients (52 hips) (38 females and 14 males) (28 right and 24 left) treated in our clinic for DGS and endoscopic sciatic nerve release in the subgluteal space between November 2011 to April 2015. Thirty-nine patients reported good to excellent outcomes. The mHHS went from 52 pre-operative to 79 post-operatives on average. Thirteen patients reported to be better but not good and required continued narcotic use after surgery [6].

28.8 The Future

- Further refinement in the diagnosis and management of deep gluteal space pathologies will certainly be seen in the future. New technologies as Deep gluteal space exploration by using carbon dioxide (CO_2) gas as an insufflation medium can add value to procedures performed in this space in order to simplify the technical aspects of the procedure while decreasing complications [33].
- Currently we are researching in the role of the "Paradoxical" function of psoas muscle (It's contraction causes the stretching of the L1,2,3,4 roots and piriformis contraction as a saving reaction) and the role of concomitant psoas fractional lengthening in deep gluteal space problems.
- Biological enhancement of sciatic nerve regeneration with intraneural plasma rich growth factors could give better results (Video 28.16).

28.9 Conclusion

There is an explosion of knowledge that is taking place as it relates to the diagnosis and treatment of the entities in the subgluteal space. Endoscopic decompression of the sciatic nerve appears useful in improving function and diminishing hip pain in subgluteal sciatic nerve entrapments.

Tips and Tricks

Sciatic nerve release

- Perform all distal sciatic decompression before any proximal work.
- A blunt dissector, such as a switching stick, can be employed for release of scar bands from the sciatic nerve.
- Fibrovascular tissue can also be cauterized with a radiofrequency probe.
- Identify possible anatomical variations of the sciatic nerve above all the type 2 of Beaton.
- The kinematic excursion of the sciatic nerve is then assessed with the leg in flexion with internal/external rotation and full extension with internal/external rotation in order to assess not only the mobility but also for any evident of impingement.
- Scar formation around the nerve can be control with antiadhesion gels in order to prevent painful scar neuropathy.

Piriformis tenotomy

- Constant attention must be paid to the branches of the inferior gluteal artery lying in proximity to the piriformis muscle.
- In many cases, a thick tendon can hide under the belly of the piriformis overlying the nerve. A rotatory shaver can be used to shave the distal border of the piriformis muscle to gain adequate access to the piriformis tendon.
- Grasp the tendon with arthroscopic scissors and pull the scissors toward you to ensure only the tendon is released. A radiofrequency probe can also be used to release the tendon with a 3 s interval of activation, maintaining continuous irrigation.

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