



HAL
open science

Limitations of arthroscopy for managing coxa profunda

Xavier Flecher, Michaël Wettstein, Olivier May

► **To cite this version:**

Xavier Flecher, Michaël Wettstein, Olivier May. Limitations of arthroscopy for managing coxa profunda. *Orthopaedics & Traumatology: Surgery & Research*, 2019, 105 (8), pp.S267-S274. 10.1016/j.otsr.2019.09.016 . hal-02528277

HAL Id: hal-02528277

<https://hal.science/hal-02528277v1>

Submitted on 14 Apr 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Limitations of arthroscopy for managing coxa profunda

Xavier Flecher^{a,*}, Michaël Wettstein^b, Olivier May^c

^a CNRS, ISM, Department of orthopaedics and Traumatology, Aix-Marseille université, Sainte-Marguerite hospital, Institute for Locomotion, AP-HM, 13009 Marseille, France

^b Institut de traumatologie et d'orthopédie du Léman-Suisse, clinique de Genolier, 1272 Genolier, Switzerland

^c Centre de chirurgie de la hanche, clinique du sport, Medipôle Garonne, 31036 Toulouse, France

ABSTRACT

Coxa profunda is a complex entity that can result in femoro-acetabular impingement (FAI). A meticulous evaluation of the type of acetabular overcoverage is essential to determine which treatment is best suited to each individual patient. Focal overcoverage with no posterior impingement can be treated by arthroscopic recontouring of the disproportionate acetabular wall. Any femoral deformities should be managed during the same procedure. General overcoverage, with predominant postero-inferior impingement, requires open surgery to obtain access to the entire acetabular rim. Rim resection should be sparing, to avoid removing an excessive proportion of the joint surface, yet sufficient to eliminate the impingement. In the event of protrusio acetabuli, which is the extreme form of coxa profunda, reverse peri-acetabular osteotomy should be considered, particularly if the acetabular roof angle is reversed. In some patients, chiefly those with coxa vara, valgus femoral osteotomy should be considered as a means of redirecting the loads towards the acetabular roof, thereby diminishing the forces that tend to drive the femoral head deeper into the socket.

Keywords:

Hip
Coxa profunda
Diagnosis
Treatment
Arthroscopy
Surgical dislocation
Periacetabular osteotomy

1. Introduction

The identification of femoro-acetabular impingement (FAI) has proved a major breakthrough in the understanding of early hip osteoarthritis. FAI causes hip pain in young individuals and may promote the early development of degenerative lesions, thus possibly being among the main causes of apparently primary hip osteoarthritis [1–3]. FAI is due to abnormalities in femoral or acetabular geometry, which are responsible for cam or pincer impingement mechanisms, respectively. Cam and pincer FAI may be present concomitantly. In pincer impingement, the acetabular overcoverage of the femoral head may be focal, due to abnormal extension of the anterior acetabular rim, or general, due to coxa profunda with protrusio acetabuli.

The first description of the morphological abnormalities that characterise protrusio acetabuli was written by Otto in 1816 [4]. In 1935, Overgaard [5] suggested the first useful classification, which distinguishes primary from secondary cases. A subsequent modification by Gilmour produced the classification that is now most widely used [6]. This classification separates secondary forms, due to an underlying condition, from primary forms, for which no cause

is detectable. The conditions capable of causing secondary protrusio acetabuli is now known to extend across a broad spectrum, from infection and trauma to metabolic, neoplastic, and genetic diseases [7]. Primary protrusio acetabuli is typically bilateral and more common in females than in males [6,8]. Protrusio acetabuli results in secondary medial osteoarthritis with little change to the superior joint line.

Orthopaedic surgeons should be familiar with the parameters used to characterise acetabular geometry, which can be designated collectively by the term acetabulometry. Among acetabular deformities, coxa profunda requires a complex diagnostic strategy. In addition, the best treatment for coxa profunda is not agreed on, and either arthroscopic or open surgery may be optimal depending on the situation. The objective of this article is to review the surgical treatment options available for FAI due to coxa profunda in adults.

2. Anatomical classification

The acetabular bone deformities that cause pincer FAI include focal (anterior) overcoverage and general abnormalities affecting acetabular orientation (retroversion) or position (coxa profunda, protrusio acetabuli). These abnormalities can be assessed by a radiographic work-up with antero-posterior, faux-profil (Lequesne), and lateral Dunn views of the painful hip, as well as

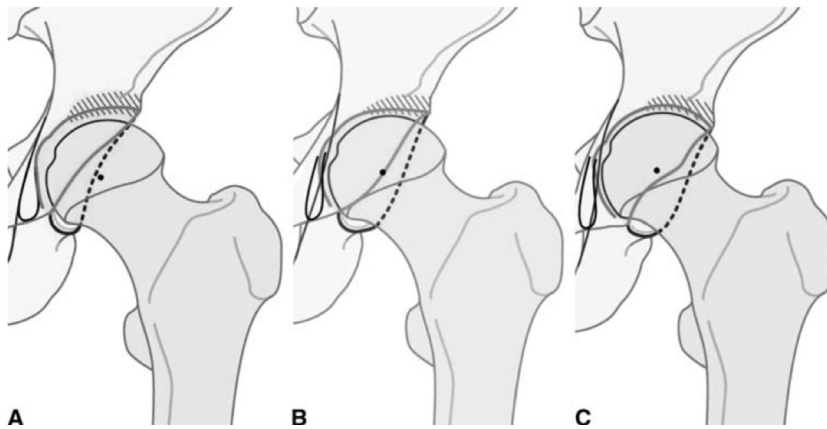


Fig. 1. Definition of coxa profunda [9]. A. In the normal hip, the acetabulum provides adequate coverage of the femoral head; B. In coxa profunda, the head is in a more medial position and the acetabular fossa (teardrop) is on or below the ilio-ischial line; C. In protrusio acetabuli, the femoral head is medial to the ilio-ischial line, acetabular roof obliquity is negative, and the centre of the femoral head is medial to the anterior and posterior acetabular walls (Tönnis angle $< 0^\circ$).

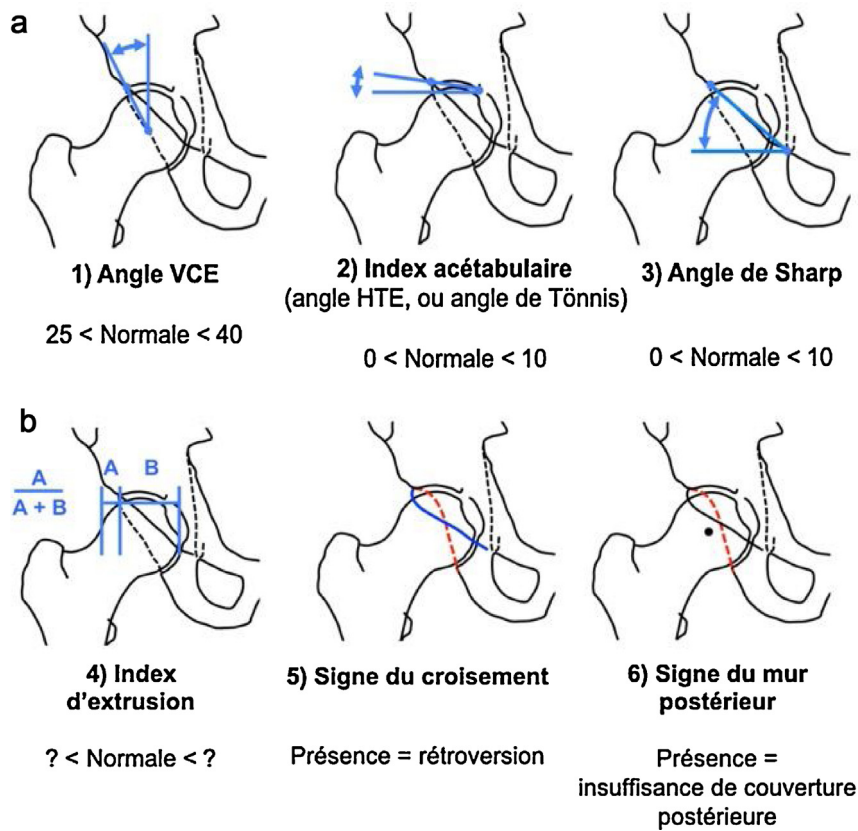


Fig. 2. a-b: Normal hip angle variables on the antero-posterior radiograph. (1) Wiberg vertical-centre-edge (VCE) angle [11]; (2) Tönnis horizontal-tectum-edge (THE) angle [12]; (3) Sharp angle [13]; Other parameters include the (4) extrusion index, (5) cross-over sign, and (6) posterior wall sign [14].

an antero-posterior view of the pelvis. Induced lesions must be evaluated by combined slice imaging and arthrography [computed tomography (CT)-arthrography or magnetic resonance (MR)-arthrography].

Coxa profunda is defined as the location of the acetabular fossa medial to the ilio-ischial line on an antero-posterior radiograph obtained using a standardised protocol (Fig. 1) [10]. This abnormally medial and lateral position of the acetabulum may be combined with predisposing anatomical characteristics, which should be evaluated by acetabulometry.

Acetabulometry consists in evaluating the position and 3D orientation of the acetabulum on a standing antero-

-posterior radiograph of the pelvis, in addition to measuring the classic hip angles (Fig. 2). The radiograph must be obtained according to a standardised protocol to eliminate variations due to pelvic rotation or tilting [15]. The radiograph should be taken under fluoroscopic guidance to align the pubic symphysis on the tip of the coccyx (to eliminate rotational malposition) and to keep 2-3 cm between the two structures (to eliminate any effect of pelvic tilt).

A classic concomitant of coxa profunda (Fig. 3) is a decrease in the extrusion index. Inconsistently present findings include an increase in lateral coverage (Wiberg CE angle [11] $> 40^\circ$ and Tönnis HTE angle [12] < 0) and retroversion (producing a positive

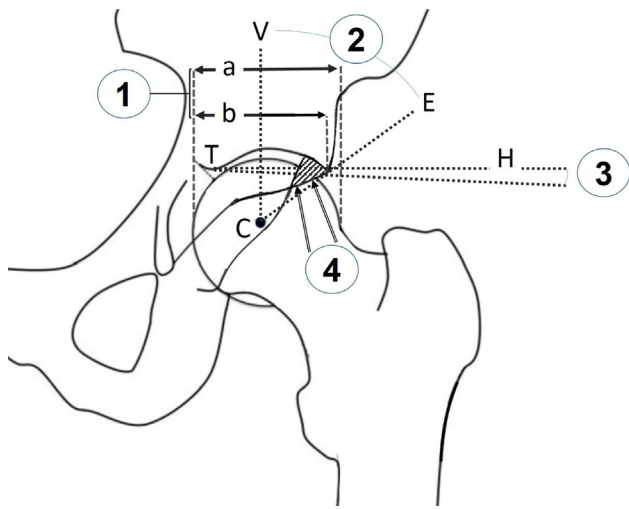


Fig. 3. A classic concomitant of coxa profunda (Fig. 3) is a decrease in the extrusion index. Inconsistently present findings include an increase in lateral coverage (Wiberg CE angle [11] $> 40^\circ$ and Tonnis HTE angle [12] < 0) and retroversion (with a positive cross-over sign) [14] with or without posterior insufficiency (posterior wall sign) [14].

cross-over sign) [14] with or without posterior insufficiency (posterior wall sign) [14]. Identification of these concomitant deformities is important to guide the choice between arthroscopy only or reverse periacetabular osteotomy to redirect the acetabulum [16].

Slice imaging after contrast injection is indispensable to assess induced lesions of the labrum and cartilage. CT-arthrography or, more classically, MR-arthrography are used with radial slices around the femoral neck axis. Finally, the presence of osteoarthritis, even at its early stage (Tonnis grade 2 or 3) [12] contraindicates conservative treatments including arthroscopic procedures.

3. Arthroscopic treatment

Arthroscopic procedures have become the reference standard for the treatment of FAI [17–21]. The arthroscopic treatment of pincer FAI involves either lateral wall acetabuloplasty or trimming of the prominent rim to eliminate the impingement. In coxa profunda, the acetabular overcoverage should be corrected if the VCE angle exceeds 40° [22,23]. Overcoverage is not always generalised, and the zones requiring acetabuloplasty should therefore be identified during surgical planning [24]. When anterior acetabuloplasty must be combined with lateral and/or postero-lateral acetabuloplasty, the procedure is more complicated.

Resection is easier to perform with traction applied to the hip. Traction is particularly helpful for the procedures on the labrum (detachment, suture, reconstruction, excision) or cartilage (debridement, microfractures, grafting). In coxa profunda, hip distraction is particularly difficult to achieve and may not be feasible. The introduction of instruments into the central part of the joint may cause iatrogenic injuries to the labrum and cartilage if the space is tight. Furthermore, the greater traction forces needed to achieve sufficient decoaptation carry a risk of injury to the nerves, perineum, and other structures. Finally, the angle of instrument introduction through the central portal is blocked by the bony acetabular rim, since the roof angle is equal to zero or negative in coxa profunda.

Two situations can therefore be distinguished in coxa profunda, depending on whether hip distraction is sufficient to allow arthroscopic procedures in the central zone or is, instead, insufficient, requiring that the arthroscopic procedures be confined to the peripheral area. However, bone resection laterally and



Fig. 4. Left hip, anterior supra-labral acetabuloplasty using a motorised burr in the peripheral zone, without traction. Postero-anterior view.

anteriorly, combined with the prior capsulotomy in the peripheral zone, may allow access to the central zone for the procedures on the labrum and cartilage, as performed for classic pincer FAI [25]. Consequently, once the peripheral procedures have been completed, a further traction attempt is advisable.

Fluoroscopy seems to provide valuable orientation in this situation. Once muscle relaxation has set in due to the anaesthesia, and before draping, fluoroscopy during axial traction shows the amount of joint distraction, thus determining whether the central zone can be accessed or whether the procedures should start in the peripheral zone; 1 cm of decoaptation is often used as the cut-off [26]. In addition, by travelling along the neck on the axial profile, fluoroscopy allows measurement of the anterior and lateral head-neck offset, which may be corrected if needed.

When the space achieved by decoaptation is sufficient, standard techniques for correcting pincer FAI are applied [27]. In addition, the postero-lateral overcoverage must be corrected. However, this situation is uncommon, and in most cases the space remains very tight. The arthroscopic procedures must then be confined to the peripheral zone. To achieve anterior, lateral, and postero-lateral acetabuloplasty using only the peripheral approach, the arthroscopic portals can be slightly modified, with the main goal of making the postero-lateral acetabular rim accessible to a motorised burr, which is often challenging with the standard portals. Two portals are usually sufficient. The most lateral paratrochanteric portal, or a postero-lateral paratrochanteric portal (between the antero-lateral and postero-lateral portals), [28] should be established, if needed with 1 cm of proximal translation. This portal resembles that described by M. Dienst for accessing the peripheral part of the joint [27]. The antero-lateral portal is preferable over the anterior portal for the other approach. The joint can be exposed by inside-out or outside-in capsulotomy according to surgeon preference.

The first step is synovectomy of the supra-labral recess to expose the acetabular rim requiring resection. As the rim is thin and the bone relatively compact (due to a microtrauma-induced increase in subchondral density), a high-speed motorised burr (e.g. 10,000 rpm) of fairly small diameter (e.g. 4 mm) is a good choice. Anterior acetabuloplasty is easiest with the arthroscope in the lateral portal and the burr in the anterior portal (Fig. 4). These positions can be switched for the lateral (Fig. 5) acetabuloplasty and postero-lateral (Fig. 6) acetabuloplasty. Fluoroscopy can be used to guide the lateral and postero-lateral resection (Figs. 7 and 8)



Fig. 5. Left hip, anterior supra-labral acetabuloplasty using a motorised burr in the peripheral zone, without traction; the superior surface of the labrum-cartilage complex is exposed by reduction of the acetabular rim. Antero-posterior view.



Fig. 6. Postero-lateral acetabuloplasty using a motorised burr in the peripheral part of the hip. Postero-lateral view.

[18], which is clearly visible on the image amplifier. In contrast, fluoroscopic guidance of the anterior acetabuloplasty is more difficult, as the bony superimpositions may obscure the contours of the acetabulum.

Resection is done as planned before the procedure. Surgical planning is more difficult because of the presence of the cross-over sign depends directly on anterior pelvic tilt. The theoretical goals include normalisation of Wiberg's CE angle [11] and disappearance of the cross-over sign after resection, without any abnormal pelvic tilt. Furthermore, Philippon et al. [29] assessed the correlation between the amount of rim reduction and the amount of CE angle reduction. They found that 1 mm of rim reduction decreased the CE angle by 2.4°, 2 mm by 3.1°, 3 mm by 3.7°, 4 mm to 4.4°, 5 mm to 5.0°, and so on. The rate of rim reduction can be assessed based on the diameter of the burr that is being used.

Current studies support preservation of the labrum [30,31]. In coxa profunda, the labrum is often hypoplastic and may therefore fail to effectively seal the joint and maintain a negative

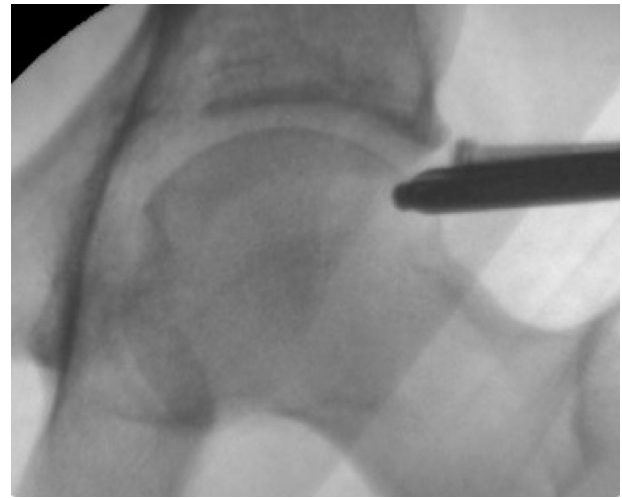


Fig. 7. Fluoroscopy during hip arthroscopy: coxa profunda, prominent anterior rim, and cross-over sign.

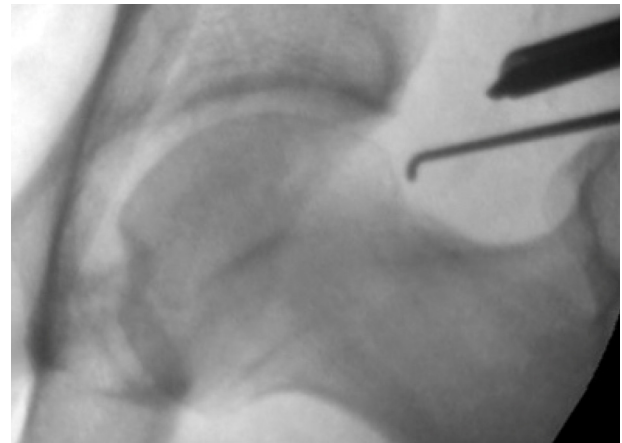


Fig. 8. Fluoroscopy at the end of the procedure: increase in the lateral coverage angle and disappearance of the cross-over sign.

intra-articular pressure. The labrum attaches to both the bone and the cartilage. Acetabuloplasty of the supra-labral rim obviates the need for detaching the labrum, which remains connected to the cartilage margin. It can be either left in place or sutured to the acetabular wall. Loop or translabral suture repair is particularly difficult to achieve without traction. Consequently, at this point a further attempt at axial traction can be performed to determine whether sufficient space is then obtained. Some authors recommend labral reconstruction, which is possible only with sufficient joint decoaptation [32].

4. Open surgical treatment

Whether open surgery is appropriate depends on the type of acetabular overcoverage: focal anterior overcoverage can be managed by arthroscopic or open resection of the deformity, whereas the indications in coxa profunda and protrusio acetabuli are more controversial.

Steppacher et al. [33] demonstrated that the joint surface is increased circumferentially in hips with coxa profunda and protrusio acetabuli and that the acetabular fossa is enlarged. These alterations increase the loads on the cranio-medial and posterior parts of the joint [34]. These biomechanical alterations, combined with the abutment mechanism typical of pincer FAI, explain the



Fig. 9. a-b: 39-year-old female with impingement related to coxa profunda of the right hip. Circumferential labral ossification. Normal hip joint line. Status after treatment of the impingement by surgical dislocation and circumferential acetabuloplasty on the left.

development of central and posterior osteoarthritis in these conditions [35].

For young patients whose cartilage is still intact, surgical techniques exist to slow the development of osteoarthritis. In coxa

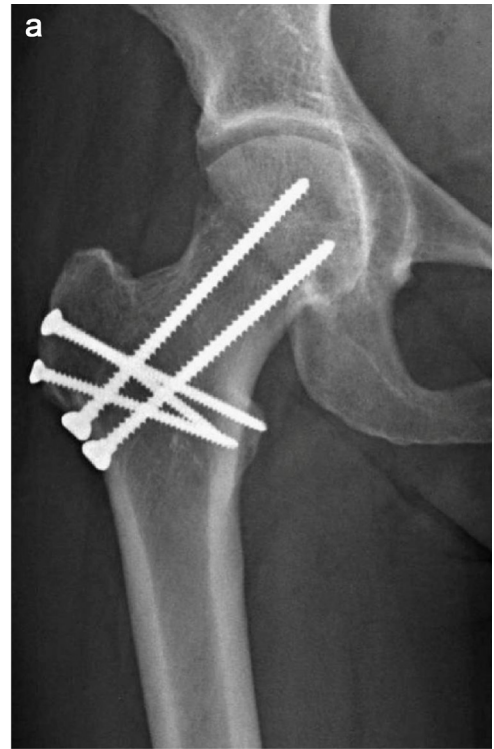


Fig. 10. a-b: Findings 9 years after treatment of the impingement by surgical dislocation on the right combined with transcervical valgus osteotomy for joint incongruity and verticalisation of the force moment during weight bearing. No further alterations of the joint line.



Fig. 11. Thirty-eight-year-old male athlete with anterior and posterior impingement and coxa profunda, acetabular retroversion, and a bilateral circumferential head-neck offset deficit.

profunda, the impingement often occurs both anteriorly, causing the contrecoup lesion, and postero-inferiorly in the event of extensive labral ossification. Whereas strictly anterior impingement can be treated locally, hip arthroscopy in these situations cannot correct the extensive deformities, and open surgery is therefore preferable. Historically, valgus osteotomy was used to verticalise the force vector, thereby encouraging medialisation of the femoral head [36]. This procedure was strikingly effective in some patients but did not always prevent progression to osteoarthritis since, at the time, the role for FAI had not been identified. Following closely on the work by the group in Bern that described FAI, studies established that pincer FAI induced osteoarthritis due to femoral head subluxation in forced flexion, causing damage to the postero-inferior acetabular and superior femoral cartilage. In this situation, the pincer mechanism must be eliminated by trimming the acetabular rim more or less extensively depending on the type of impingement (anterior only or anterior and postero-inferior). This procedure requires a surgical hip dislocation technique that provides circumferential access to the joint if the impingement is both anterior and postero-inferior [37].

In these situations, the labrum is often ossified along its entire circumference and must be resected. Although biomechanical studies have established the importance of the labrum, the effects of circumferential resection remain unclear [38]. The clinical outcomes seem poorer after labral resection compared to labral preservation, but no sound evidence is available to date, notably regarding circumferential labral resection [39–41]. Labral reconstruction using an autologous tendon graft can be considered to restore fluid sealing, although graft outcomes, particularly in terms of the risk of ossification, remain unclear [42].

In patients with coxa vara and/or impaired joint congruity, valgus osteotomy should be considered. This procedure is classically performed at the inter-trochanteric level. However, improved knowledge about the blood supply to the femoral head and the introduction of the surgical dislocation technique with the use of an extensive posterior vascular-periosteal flap may allow osteotomy at the femoral neck [43] (Figs. 9–10). Painstaking adherence to the surgical technique is essential to avoid avascular necrosis of the femoral head. Nevertheless, this procedure increases the potential for correction, since the osteotomy is performed closer to the deformity. It also considerably diminishes the risk of limb length discrepancy and avoids deformity of the proximal

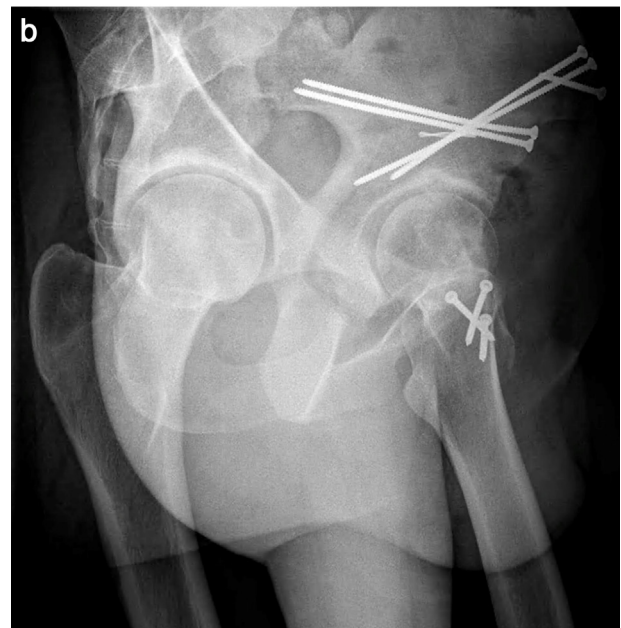
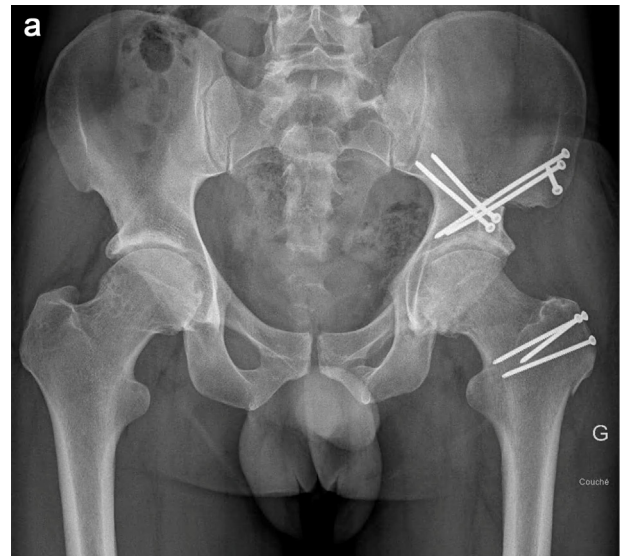


Fig. 12. a-b: Antero-posterior and faux-profil radiographs 2 months after acetabular correction by reverse peri-acetabular osteotomy and circumferential head and neck re-contouring via surgical dislocation of the left hip. The lateral coverage remains increased but normal anteversion is restored and the hip joint line is intact. Note the healing of the osteotomies.

femoral metaphysis, which might complicate the subsequent implantation of a femoral stem. Fixation of the osteotomy can be achieved using simple screws, and the risk of post-operative pain due to the fixation material classically used to fix inter-trochanteric osteotomies is therefore reduced. In all these situations, any concomitant femoral deformity responsible for cam impingement should be corrected, regardless of the other techniques used.

Protrusio acetabuli raises greater challenges, since the frequently reversed slope of the acetabular roof promotes medialisation of the femoral head [44]. In this situation, acetabular recontouring, even when circumferential, fails to provide satisfactory outcomes, notably when the protrusio acetabuli or coxa profunda is accompanied with acetabular retroversion [9]. Extensive surgery must therefore be performed, with surgical dislocation, circumferential acetabular and femoral head recontouring, trimming of the prominent acetabular rim, resection

of the usually ossified labrum, and acetabular re-orientation by reverse periacetabular osteotomy (Figs. 11-12). Although this method may seem invasive, biomechanical studies have demonstrated that it decreases cartilage loading and may therefore produce better long-term outcomes in these challenging cases [34].

As mentioned above, these surgical procedures are completely safe provided the technique is scrupulously adhered to. However, the indication should be carefully assessed in the light of the presence of osteoarthritis lesions of the hip at the time of surgery. In younger patients, more extensive surgery may be warranted to preserve the native hip as long as possible. In contrast, in the event of substantial cartilage damage, which is often present in patients with FAI after 40 years of age, hip arthroplasty may be the best option.

5. Conclusions

Coxa profunda must be among the diagnoses considered in patients with groin pain consistent with FAI. When the cartilage is intact, conservative surgical procedures may be used. Some of these procedures can be performed arthroscopically, although the technique is demanding. Thus, arthroscopy can be used for recontouring confined to the anterior part of an acetabulum that is normally anteverted and not hypoplastic. When these criteria are not met, pelvic and/or femoral osteotomies should be considered for conservative treatment.

Disclosure of interest

X. Flecher (consultant for Stryker endoscopy, Zimmer Biomet).
Olivier May: consultant for Smith and Nephew.
M. Wettstein declares that he has no competing interest.

Funding sources

None.

Authors' contribution

Writing of the manuscript (X. Flecher, O. May, M. Wettstein).

References

- [1] Ganz R, Parvizi J, Beck M, Leunig M, Notzli H, Siebenrock KA. Femoroacetabular impingement: a cause for osteoarthritis of the hip. *Clin Orthop Relat Res* 2003;417:112–20.
- [2] Beck M, Kalhor M, Leunig M, Ganz R. Hip morphology influences the pattern of damage to the acetabular cartilage: femoroacetabular impingement as a cause of early osteoarthritis of the hip. *J Bone Joint Surg Br* 2005;87:1012–8.
- [3] Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. *Clin Orthop Relat Res* 2008;466:264–72.
- [4] Otto AW. Ein Becken, mit kugelformig auge dehnten Pfannen. In: Heft E, editor. *Seltene Beobachtungen zur Anatomie, Physiologie und Pathologie* georig. 9. Breslau: Verlag Willibald August Holaufer; 1816. p. 19–20.
- [5] Overgaard K. Otto's disease and other forms of protrusio acetabuli. *Acta Radiologica* 1935;16:390–419.
- [6] Gilmour J. Adolescent deformities of the acetabulum: an investigation into the nature of protrusio acetabuli. *Brit J Surg* 1939;26:670–99.
- [7] Dunlop CC, Jones CW, Maffulli N. Protrusio acetabuli. *Bull Hosp Jt Dis* 2005;62:105–14.
- [8] Alexander C. The aetiology of primary protrusio acetabuli. *Br J Radiol* 1965;38:567–80.
- [9] Leunig M, Huff T, Ganz R. Femoroacetabular impingement: Treatment of the acetabular side. In: Azar FM, O'Connor MI, editors. *Instructional Course Lectures* 58. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2009. p. 223–9.
- [10] Leunig M, Nho SJ, Turchetto L, Ganz R. Protrusio acetabuli: New insights and experience with joint preservation. *Clin Orthop Relat Res* 2009;467:2241–50.
- [11] Wiber G. The anatomy and roentgenographic appearance of a normal hip joint. *Acta Chir Scand* 1939;83:7–38.
- [12] Tönnis D. *Congenital dysplasia and dislocation of the hip in children and adults*. New York, NY: Springer; 1987.
- [13] Sharp IK. Acetabular dysplasia (The acetabular angle). *J Bone Joint Surg Br* 1961;43:268–72.
- [14] Reynolds D, Lucas J, Klauke K. Retroversion of the acetabulum. A cause of hip pain. *J Bone Joint Surg Br* 1999;81-2:281–8.
- [15] Tannast M, Zheng G, Anderregg C, Burckhardt K, Langlotz F, Ganz R, et al. Tilt and rotation correction of acetabular version on pelvic radiographs. *Clin Orthop Relat Res* 2005;438:182–90.
- [16] Sierra RJ. The management of acetabular retroversion with reverse periacetabular osteotomy. *Instr Course Lect* 2013;62:13–35.
- [17] Byrd JW, Jones KS. Arthroscopic femoroplasty in the Management of Cam-Type Femoroacetabular Impingement. *Clin Orthop Relat Res* 2009;467:739–46.
- [18] Gedouin JE, May O, Bonin N, Nogier A, Boyer T, Sadri H, et al. French Arthroscopy Society. Assessment of arthroscopic management of femoroacetabular impingement. A prospective multicenter study. *Orthop Traumatol Surg Res* 2010;96:59–67.
- [19] Khanduja V, Villar RN. The arthroscopic management of femoroacetabular impingement. *Knee Surg Sports Traumatol Arthrosc* 2007;15:1035–40.
- [20] Philippon M, Briggs KK, Yen YM. Outcomes following hip arthroscopy for femoroacetabular impingement with associated chondrolabral dysfunction: minimum two-year follow-up. *J Bone Joint Surg Br* 2009;91:16–23.
- [21] Sampson TG. Arthroscopic treatment. Arthroscopic treatment for chondral lesions of the hip. *Clin Sports Med* 2011;30:331–48.
- [22] Anderson LA, Peters CL. Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. *J Bone Joint Surg Am* 2009;91:305–13.
- [23] Tönnis D, Heinecke A. Acetabular and femoral anteversion: relationship with osteoarthritis of the hip. *J Bone Joint Surg Am* 1999;81:1747–70.
- [24] Anderson LA, Kapron. Coxa profunda: is the deep acetabulum overcovered? *Clin Orthop Relat Res* 2012;470:3375–82.
- [25] Gédouin JE, Bonin N. Conflit Fémoro-acétabulaire: traitement, indications, résultats. *L'Arthroscopie*: Elsevier; 2015. p. 687–95.
- [26] Krantz N, Jan N, Delay C, May O. Arthroscopie de la hanche: installation et voies d'abord. *L'Arthroscopie*: Elsevier; 2015. p. 659–66.
- [27] Dienst M, Gödde S, Seil R, Hammer D, Kohn D. Hip arthroscopy without traction: In vivo anatomy of the peripheral hip joint cavity. *Arthroscopy* 2001;17:924–31.
- [28] Matsuda DK. Fluoroscopic Templating Technic for Precision Arthroscopic Rim Trimming. Technical note with video illustration. *Arthroscopy* 2009;25:1175–82.
- [29] Philippon MJ, Wolff AB, Briggs KK, Zehms CT, Kuppersmith DA. Acetabular rim reduction for the treatment of femoroacetabular impingement correlates with preoperative and postoperative center-edge angle. *Arthroscopy* 2010;26:757–61.
- [30] Cadet ER, Chan AK, Vorys GC, Gardner T, Yin B. Investigation of the preservation of the fluid seal effect in the repaired, partially resected, and reconstructed acetabular labrum in a cadaveric hip model. *Am J Sports Med* 2012;40:2218–23.
- [31] Naal FD, Miozzari HH, Schär M, Hesper T, Nötzli HP. Midterm results of surgical hip dislocation for the treatment of femoroacetabular impingement. *Am J Sports Med* 2012;40:1501–10.
- [32] Mook WR, Briggs KK, Philippon MJ. Evidence and approach for management of labral deficiency: The role for labral reconstruction. *Sports Med Arthrosc Rev* 2015;23:205–12.
- [33] Steppacher SD, Lerch TD, Gharanzadeh K, Liechti EF, Werlen SF, Puls M, et al. Size and shape of the lunate surface in different types of pincer impingement: theoretical implications for surgical therapy. *Osteoarthritis Cartilage* 2014;22:951–8.
- [34] Liechti EF, Ferguson SJ, Tannast M. Protrusio acetabuli: joint loading with severe pincer impingement and its theoretical implications for surgical therapy. *J Orthop Res* 2015;33:106–13.
- [35] Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. *Clin Orthop Rel Res* 2008;466:264–72.
- [36] McBride MT, Muldoon MP, Santore RF, Trousdale RT, Wenger DR. Protrusio acetabuli: diagnosis and treatment. *J Am Acad Orthop Surg* 2001;9:79–88.
- [37] Ganz R, Gill TJ, Gautier E, Ganz K, Krügel N, Berlemann U. Surgical dislocation of the adult hip. A technique with full access to the femoral head and acetabulum without the risk of avascular necrosis. *J Bone Joint Surg Br* 2001:1119–24.
- [38] Chegini S, Beck M, Ferguson SJ. The effects of impingement and dysplasia on stress distributions in the hip joint during sitting and walking: a finite element analysis. *J Orthop Res* 2009;27:195–201.
- [39] Espinosa N, Rothenfluh DA, Beck M, Ganz R, Leunig M. Treatment of femoroacetabular impingement: preliminary results of labral refixation. *J Bone Joint Surg Am* 2006;88:925–35.
- [40] Philippon M, Stubbs A, Schenker M, Briggs K. Factors Associated with Revision Hip Arthroscopy (SS-60). *Arthroscopy* 2006;22:e30–1.

- [41] Costa Rocha P, Klingenstein G, Ganz R, Kelly BT, Leunig M. Circumferential reconstruction of severe acetabular labral damage using hamstring allograft: surgical technique and case series. *Hip Int* 2013;23:S42–53.
- [42] Locks R, Bolia IK, Utsunomiya H, Briggs KK, Philippon MJ. Revision hip arthroscopy after labral reconstruction using iliotibial band autograft: surgical findings and comparison of outcomes with labral reconstructions not requiring revision. *Arthroscopy* 2018;34:1244–50.
- [43] Leunig M, Slongo T, Kleinschmidt M, Ganz R. Subcapital correction osteotomy in slipped capital femoral epiphysis by means of surgical hip dislocation. *Oper Orthop Traumatol* 2007;19:389–410.
- [44] Tannast M, Leunig M, Session P. Report of breakout session: Coxa profunda/protrusio management. *Clin Orthop Relat Res* 2012;470:3459–61.