Subspine Impingement and Surgical Technique

63

Lazaros A. Poultsides and Bryan T. Kelly

Contents

Abstract

Femoroacetabular impingement is one of the causes of hip pain leading to acetabular labral tears and cartilage damage via mechanical overload that may lead to the development of early osteoarthritis. Recently, other causes of impingement have been described that may be associated with the painful nonarthritic hip. Anterior inferior iliac spine (AIIS)/subspine impingement is caused by abnormal contact between the AIIS and proximal femur with straight hip flexion. Recently, a classification system of the AIIS morphology has been proposed which may provide valuable information for the preoperative surgical plan. Radiographs, magnetic resonance imaging, ultrasound, or computed tomography may help to better elucidate the problem and differentiate between intra- and extra-articular pathology. The rationale of arthroscopic subspine decompression procedure has been supported recently demonstrating favorable results. Complex AIIS morphologies combined with significant intra-articular pathology can make the arthroscopic procedure challenging. Since long-term outcomes of arthroscopic subspine decompression are still forthcoming, safety should be the first priority. This can be accomplished by following specific principles such as detailed preoperative planning by utilizing advanced imaging modalities, avoidance of long traction times, and fluoroscopic imaging intraoperatively to assure adequate and accurate AIIS and cam resection.

L.A. Poultsides (✉)
Department of Orthopaedic Surgery, Center for Hip Pain and Preservation, Hospital for Special Surgery, New York, NY, USA
e-mail: PoultsidesL@HSS.EDU

B.T. Kelly
Department of Orthopaedic Surgery, Center for Hip Preservation Surgery, Hospital for Special Surgery, New York, NY, USA

Weill Medical College of Cornell University, New York, NY, USA

S.J. Nho et al. (eds.), *Hip Arthroscopy and Hip Joint Preservation Surgery*,
DOI 10.1007/978-1-4614-6965-0_68

Introduction

Hip pain and dysfunction in a nonarthritic joint have typically been associated with two distinct mechanical types of femoroacetabular impingement (FAI) [1]. Cam impingement can also be described as an inclusion type of injury [1–3], where a bony deformity at the femoral head–neck junction enters the joint with hip flexion [3–5]. Pincer impingement – also known as an impaction type of injury [1–3] – occurs as a result of focal or global acetabular overcoverage, causing the neck, head–neck junction, or femoral head to impact the acetabular rim, with hip flexion [1, 6–8]; symptomatic patients most commonly have features of both types of FAI [9–13].

Furthermore, nonarthritic hip joint pain has been associated either with dynamic factors resulting in abnormal contact between the femoral head and acetabular rim when the hip is in motion or with static overload stresses related to undercoverage of the femoral head in the axially loaded position [14]. Mechanical factors related to dynamic impingement include variations in anatomy such as the cam deformity [1, 11, 15, 16], lack of head–neck offset [15], increased acetabular depth or protrusio deformity [17, 18], acetabular retroversion [1, 19–22], and, at the extremes of this spectrum, slipped capital femoral epiphysis (SCFE) [2, 3] and the sequelae of childhood Perthes' disease [23]. Recently, a newly recognized cause of pincer-/impaction-type impingement has been described, presenting as an extra-articular form of FAI and occurs when a prominent anterior–inferior iliac spine (AIIS) or subspine region impinges against the anterior or inferior/medial part of the femoral neck in straight hip flexion to over 90° (subspine impingement) [6–8].

Rectus femoris AIIS avulsion injuries leading to a deformity of the AIIS have been described as the most common cause of these AIIS deformities [24–26] and specifically between the ages of 13 and 23 years, when the ratio of muscle to physeal strength is greatest [24, 25, 27, 28]. Rectus femoris anatomy and relevant biomechanics may elucidate the pathomechanics of this type of injuries. It is fusiform in shape; its superficial fibers are arranged in a bipenniform manner, whereas the deep fibers run straight down to the deep aponeurosis. It arises by two tendons: one, the anterior or straight, from the AIIS and the other, the posterior or reflected, from a groove above the rim of the acetabulum [29]. A recently published cadaveric study by Hapa et al. [30] showed that the direct head of the rectus tendon has a broad insertion on the AIIS; in 11 male cadaveric hips, the mean proximal–distal and medial–lateral distances for the rectus origin footprint were 2.2 ± 0.1 cm (range, 2.1–2.4 cm) and 1.6 ± 0.3 cm (range, 1.2–2.3 cm), respectively. In addition, on the clock face, the lateral margin (1 o'clock to 1:30 position) and medial margin (2 o'clock to 2:30 position) of the AIIS and the indirect head of the rectus (12 o'clock) were consistent for all specimens. Authors found that the AIIS typically extended further anterior and inferomedial than the rectus footprint, leaving a typical bare area devoid of tendon in this region. This footprint anatomy may have significant clinical relevance, in cases of symptomatic AIIS impingement, regarding the safe extent of subspine decompression with respect to maintaining the integrity of the origin of the direct head of the rectus femoris tendon [30]. These two tendons unite at an acute angle and spread into an aponeurosis which is prolonged downward on the anterior surface of the muscle; from this aponeurosis, the muscular fibers arise. Rectus femoris is innervated by two branches of the femoral nerve with fibers from L3 and L4. Its function is to extend the knee by lifting the lower leg. Because of the biarticular nature of rectus femoris, the associated passive insufficiency may explain the predisposition of specific sports, requiring repetitive kicking or sprinting (i.e., soccer, football, and basketball), to avulsion injuries; rectus femoris may not be able to stretch out enough to allow knee flexion while the hip is in extension. Recently, a potentially developmental – rather than an avulsion-type injury – form of AIIS deformity and subsequent subspine impingement was described and was associated with acetabular retroversion and may in fact be the most prevalent form of subspine

Fig. 1 CT AP view of type I AIIS variant in a left hip. There is a smooth ilium wall between the caudad level of the AIIS and the acetabular rim

Fig. 2 CT AP view of type II AIIS variant in a left hip. Bony prominences (*black arrow*) are present on the ilium wall extending from the caudad area of the AIIS to the acetabular rim

impingement [6]. The relevant three-dimensional (3D) CT reconstruction views revealed a low-set AIIS with smooth and rounded borders extending to the level of the acetabular rim [6], as opposed to the spiky-spur appearance of the AIIS observed in another series [8].

In order to delineate these distinct etiologies contributing to AIIS impingement, a specific classification system has been proposed lately attempting to define indications and facilitate the surgical decision-making when managing this clinical entity [7]. Three-dimensional CT reconstructions of 53 hips (53 patients) with symptomatic FAI were evaluated [7] defining three morphological AIIS variants: type I when there was a smooth ilium wall between the AIIS and the acetabular rim, characterized by the lack of contribution from the AIIS to hip impingement (Fig. 1); type II when the AIIS extended to the level of the rim (Fig. 2); and type III when the AIIS extended distally to the acetabular rim (Fig. 3). Type III, and to a lesser extent type II variants, contributed to FAI, documented by the limitation in flexion and internal rotation and the bone contact seen between the AIIS and the femoral neck at terminal hip positions. In both type II and III cases, the AIIS may be considered and consequently has to be critically assessed as a potential contributor to hip impingement [7].

Fig. 3 CT AP view of type III AIIS variant in a left hip. The AIIS (*white arrow*) extends distally to the anterosuperior acetabular rim, characterized by a downward "spur appearance"

Systematic Approach to the Evaluation and Surgical Treatment

A systematic approach for each patient who presents with symptomatic FAI and possible subspine impingement should include combined information of a detailed history, an anatomically based clinical examination, and the interpretation of clinically relevant findings of all available imaging modalities. These diagnostic tools will enable the clinician to successfully make a "four-layered" – osteochondral, inert, contractile, and neuromechanical layer – diagnosis, which is essential to formulate a safe and successful treatment plan [31–33].

Clinical Presentation

The clinical presentation in patients with subspine impingement includes tenderness to palpation over the AIIS that recreates typical pain and anterior hip or groin pain with straight or prolonged hip flexion [34]. On physical examination, hip flexion range of motion is limited. Partial pain relief and persistent hip flexion limitations after intra-articular anesthetic hip injection may be observed [6]. This may be explained by the fact the AIIS deformity may not have been the single cause for the preoperative symptoms since studies have shown the concomitant presence of abnormal cam morphology [35]. Furthermore, cam lesions may have contributed to anterior impingement against the AIIS, consistent with recent studies that showed that impingement in such cases, when the hip was flexed to greater than 90°, occurred between the AIIS prominence and the anterior aspect of the femoral neck [6–8, 36]. In the presence of intra-articular FAI, the minimal relief of groin and/or anterior pain during straight hip flexion after intra-articular injection of a local anesthetic implies the coexistence of extra-articular subspine impingement [37]. Such cases combining both intra- and extra-articular deformity/impingement underscore the significant advantage of using the arthroscopic approach to decompress an abnormal AIIS, which enables the surgeon to address simultaneously all potential intra- and extra-articular sources of hip pathology.

Imaging Modalities

Radiographs may reveal calcification within the direct or indirect head of the rectus femoris origin, evidence of prior AIIS avulsion injury (Fig. 4), a prominent AIIS deformity, extending to the level of or caudad to the level of the anterior–superior acetabular rim (on AP view of the pelvis and lateral view of the femur), excessive anterior and distal extension of AIIS viewed on false-profile view, crossover sign with increased anterior acetabular rim sclerosis (on AP view of the pelvis), and impingement cysts located at the distal femoral neck (Fig. 5) [6–8, 38]. Impingement cysts in AIIS/subspine impingement are located more distal on the femoral neck than typically seen with FAI impingement [6–8, 39]. The 3D computed tomography (CT) images are invaluable tool for preoperative assessment [6–8]. The 3D surface rendering computed tomography images could delineate the shape and deformity of the AIIS facilitating the classification and consequently generating the appropriate for each patient surgical plan. They could provide the clinician with the specific location of osseous impingement and the unique pattern of FAI impingement in each patient (Figs. 1, 2, 3, 6, and 7a, b). Magnetic resonance imaging (MRI) may also demonstrate abnormalities of the AIIS or subspine area. This area should always be evaluated on hip MR examinations in addition to the cartilage, labrum, capsule, and periarticular soft tissues such as tendons, muscles, and bursae (Fig. 8) [34]. Except for radiography, CT, and MRI, advanced dynamic imaging

Fig. 4 AP view of the pelvis demonstrating calcification of the rectus femoris origin (*arrow*) in the left hip in an athlete with a history of chronic avulsion of the direct head of the rectus femoris that was treated nonoperatively

Fig. 5 Lateral view of the left hip of a patient with a history of chronic avulsion of the direct head of the rectus femoris. Prominent AIIS (*arrow*) extending caudad to the level of the anterosuperior acetabular rim, and herniation pits (*dotted arrow*) at the distal femoral neck confirm the presence of subspine impingement

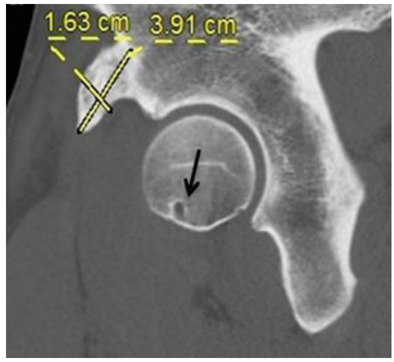

Fig. 6 CT sagittal view of a left hip (same patient with Figs. 4 and 5) showing the distal and anterior extension of the AIIS and the associated impingement cysts (*arrow*) at the distal femoral neck

modalities such as dynamic ultrasonography and three-dimensional dynamic imaging analysis could facilitate the assessment of subspine impingement. A CT-based, dynamic computer model software program (A2 Surgical, Saint-Pierred'Allevard, France) [6–8, 40] allows the execution of motion paths that may be unique for each painful hip. Reproduction of zones of proximal femoral and prominent AIIS and/or acetabular bone-to-bone contact, via straight flexion beyond 90°, offers great insights for preoperative planning and could tailor the appropriate treatment of each patient (Fig. 9a, b) [41].

Treatment: Arthroscopic Approach

Decompression of a symptomatic AIIS prominence was described in the past, through the Smith-Petersen approach, either as a single procedure [24] or after arthroscopic exploration of the joint [36], but recently, the concept of arthroscopic decompression has been popularized in several studies demonstrating satisfactory short-term results [6–8, 30]. The rationale of arthroscopic decompression of prominent AIIS is supported by short-term outcomes series showing improvement in hip function and ROM [8]. This type of extra-articular arthroscopic procedure appears to be safe given that no associated complications have been reported. Despite the proximal and possible medial dissection of the capsule, no cases of fluid extravasation into the abdomen or retroperitoneum were observed. Furthermore, no cases of postoperative hip flexion weakness, complete detachment of the direct head of rectus femoris insertion from the AIIS, or formation of heterotopic ossification (HO) have been described. The concept of arthroscopic subspine decompression in AIIS variants that extend to and below the acetabular rim is further emphasized by a recent study [7]. In a cohort where FAI patients were matched for age, femoral version, and alpha angles, a CT-based dynamic computer model revealed that these prominent types of AIIS were associated with a decrease in hip flexion and internal rotation compared to the normal AIIS variants [7].

The significant advantage of arthroscopic approach is that it allows the hip surgeon to address patients with coexisting intra- and extra-articular causes of hip pain by utilizing a single arthroscopic procedure [6–8]. Preoperative planning is of paramount importance and should include 3D CT reconstruction views to evaluate the extension of the AIIS prominence, both anteriorly and distally. Should a cam deformity be present, concomitant decompression could be performed to increase the range of straight flexion without bone-to-bone contact. Any intra-articular

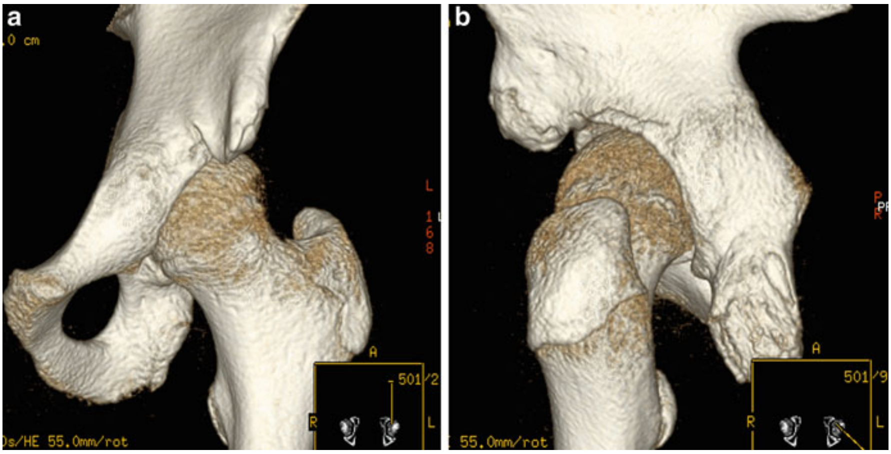

Fig. 7 **a**–**b** The prominent AIIS is well demonstrated in the 3D CT reconstruction AP view (**a**) and the "ischium AIIS" view (**b**) of this left hip before arthroscopic subspine decompression was performed

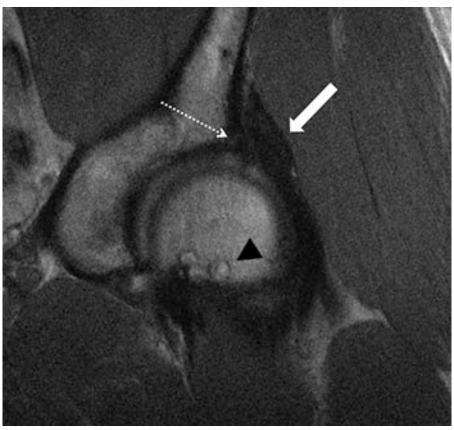

Fig. 8 MRI coronal view of a left hip (same patient with Figs. 4, 5, and 6) revealing thickening of the rectus femoris (*arrow*) secondary to chronic avulsion of the direct head of the rectus femoris that was treated nonoperatively, anterosuperior labral tear (*dotted arrow*) and associated herniation pits (*arrowheads*) at the distal femoral neck

abnormalities, such as labral or chondral injury, should be addressed as well to optimize the surgical outcome. The development of advanced and less invasive arthroscopic techniques, including extensile arthroscopic capsulotomies, has improved the central and peripheral compartment access and visualization facilitating, therefore, acetabular rim and AIIS evaluation and resection, treatment of labral and chondral injury, and osteoplasty for cam decompression.

Surgical Technique

The positioning of the patient depends on surgeon preference, but for both supine and lateral positions, the feet should be well padded, and a large perineal pad should be used to optimize distraction and to minimize traction-related complications, such as pudendal nerve injury. Adequate distraction results in approximately 10 mm of joint space opening confirmed by fluoroscopy. Majority of surgeons utilize either two or three portals depending on their preoperative plan and preference. The two most widely accepted portals are the anterolateral (lateral) and the true anterior or modified anterior portal. Additional used portals are the distal anterolateral accessory portal (DALA) and various percutaneous distal portals that facilitate the anchor placement, especially in the anterior acetabular rim, suture management, and work (femoroplasty and capsule closure) in the peripheral compartment. The aforementioned portals allow better visualization and safe access to the hip joint [42]. The anterolateral pertrochanteric portal is established first under fluoroscopic guidance, followed by the mid-anterior portal (slightly more lateral to the traditional anterior to avoid injury to the lateral femoral cutaneous nerve) under arthroscopic visualization from the lateral portal. The mid-anterior portal may be placed more distally in cases with

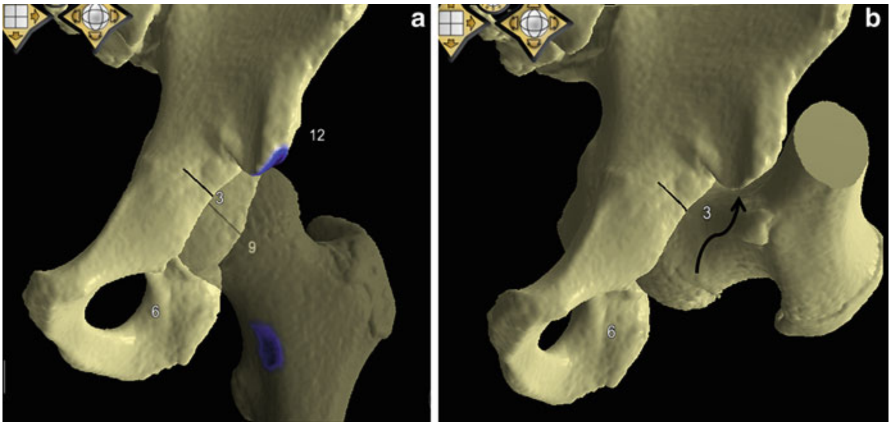

Fig. 9 **a**–**b** CT-based dynamic software images of a left hip showing areas of impingement between a type III AIIS (extending caudad to the level of the anterosuperior acetabular rim) and the distal femoral neck. (**a**) Hip in neutral position. The *blue* color highlights the area of bony impingement of the AIIS against the inferior part of the femoral neck with straight flexion. (**b**) Hip in 112° of flexion. The *curved arrow* illustrates the area of AIIS impingement

AIIS impingement in order to facilitate access to the anterior portion of the joint. Care should be taken to keep minimum 6–7 cm between the portals, which will allow sufficient working space between instruments. Having established the lateral and mid-anterior portals, based on each patient's individual bone anatomy, a diagnostic arthroscopy is performed to evaluate the labrum, capsule, femoral head and acetabular cartilage, and ligamentum teres (Fig. 10a). The interpretation and correlation of intraoperative findings with the clinical examination and imaging findings will confirm the layered diagnosis and enable the surgeon to follow the preoperative surgical plan. Afterwards, the interportal cut is performed, connecting the anterolateral with the mid-anterior portal. This capsular cut will improve the visualization and enable the surgeon to work on the acetabular rim and subspine area. It should be limited only to the area of labral injury because unnecessary capsular cutting beyond the two portals may lead to postoperative capsular instability, especially in the setting of static overload such as acetabular undercoverage, increased femoral or acetabular version, femoral valgus, and dynamic instability [43, 44].

Based on preoperative imaging and intraoperative visualization, the margins of the AIIS abnormality and associated capsular-sided labral damage are defined. Depending on the distal and anterior extension of the AIIS in relation to the acetabular rim, the degree of labral damage and capsular-sided erythema may vary in severity. The capsule is then elevated off in this area using both low-energy radiofrequency ablation and motorized shavers bur (extra-long 5.5-mm full radius), but care is taken not to primarily detach the labrum from the rim. A flexible radiofrequency probe may be helpful to dissect the capsule around the AIIS and in the area of acetabular rim if focal overcoverage coexists (Fig. 10b). After the capsule has been elevated, and the AIIS is fully exposed, subspine decompression can be performed utilizing motorized burs (5.5 mm in diameter) (Fig. 10c). Resection of the prominent AIIS can be confirmed both arthroscopically and under fluoroscopic imaging (Figs. 10d, 11). Over-resection proximally should be avoided in order not to endanger the insertion of the direct head of rectus femoris; if it is significantly destabilized, reattachment may be required although this complication has not been reported in the literature to date. If the prominence of the AIIS extends medially as well, decompression of the medial border should be performed especially if there are clinical, radiological, and intraoperative findings of symptomatic psoas impingement against the AIIS. The medial portion

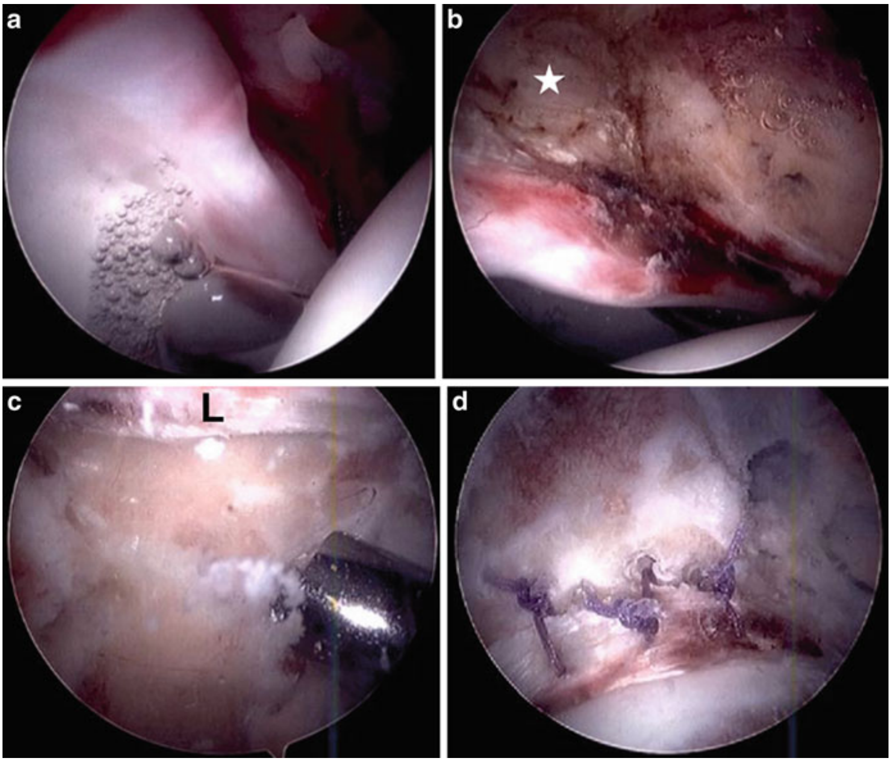

Fig. 10 **a**–**d** (**a**) View from the anterolateral portal in a right hip showing no discreet labral detachment, no cartilage wear on the femoral head, early grade 1 chondral delamination on transition zone cartilage from cam lesion, and anterior capsular inflammation. (**b**) View from the anterolateral portal demonstrating significant capsular-sided labral erythema, rectus inflammation, and distal extension of the AIIS (*white asterisk*) below the acetabular rim. (**c**) Subspine decompression with a 5.5 mm bur. View from the mid-anterior portal confirms that the resection of the acetabular rim distally to the AIIS extends all the way to the transition zone of the chondrolabral junction. (**d**) Arthroscopic view showing adequate subspine decompression, rim correction, and labral refixation. *L* labrum

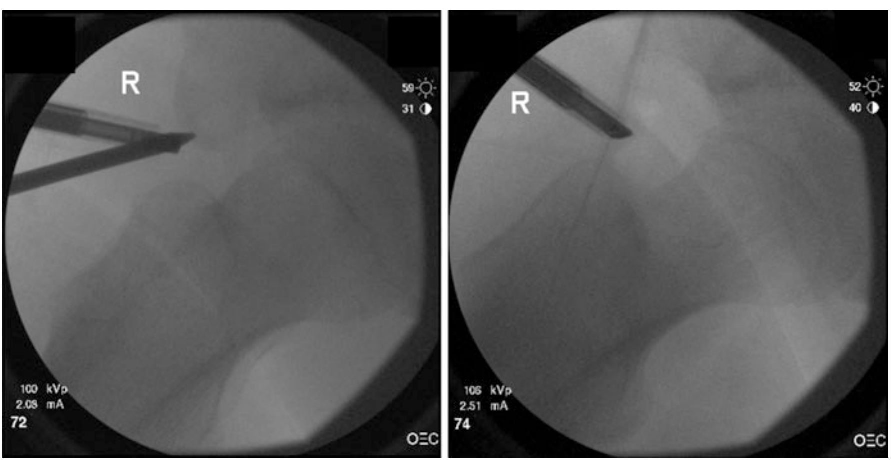

Fig. 11 *Left*, intraoperative fluoroscopic view of the same patient (Fig. 10a–d) demonstrating the prominent AIIS and anterior cam lesion. *Right*, after subspine and cam decompression, the AIIS shape is no longer extending distally and anteriorly, and the head–neck offset is recreated along the anterior femoral neck

of the AIIS has been shown to be devoid of tendinous origin and a safe zone for decompression [30]. If the estimated time of traction will exceed 90 min due to significant work required in the central compartment (rim trimming, AIIS resection, labral repair), then the AIIS decompression can be performed or completed without traction to decrease the incidence of extended traction-related complications [45]. Potential disadvantage of this approach is that after completion of the AIIS decompression, labral attachment integrity should be reassessed. When the AIIS prominence extends straight distally to the rim level and therefore significant bone resection may be required, the labrum may need to be repaired at the completion of the decompression, which is not possible without traction. The subspine decompression is considered successful when the resection of the acetabular rim distally to the AIIS extends all the way to the transition zone of the chondrolabral junction minimizing, thus, the likelihood for residual postoperative rim-impaction impingement (Fig. 10c). However, intraoperative fluoroscopy should be used to confirm the extent of AIIS resection, especially distally (Fig. 11). Radiological and intraoperative recognition of the extent of the AIIS prominence relative to the acetabular rim both anteriorly and distally is of paramount importance. It has been shown that AIIS extending to or below the level of the anterior–superior acetabular rim may be partially or completely responsible for the appearance of a radiographic crossover sign in hips with anteverted acetabulum [46]. The use of fluoroscopic imaging may prevent unnecessary resection of acetabular hyaline cartilage and production of iatrogenic acetabular dysplasia. In the setting of normal acetabular version, preoperative crossover sign on a well-positioned AP view of the pelvis may be corrected after adequate isolated AIIS resection [46]. Extended subspine decompression combined with rim resection and damage to the transition zone cartilage may necessitate labral refixation. Destabilized labrum should be reattached to the rim with modern arthroscopic techniques (Fig. 10d). At this point, a third portal is established; the DALA portal is placed in line with the anterolateral portal, approximately 5 cm distally which will enable the positioning of the anchor/anchors along the acetabular rim and could be used as a working portal for the femoroplasty in the peripheral compartment later, if needed. Depending on the femoral torsion, the DALA portal may be placed slightly more anterior in retroverted femurs to reduce the possibility of instruments' impaction against the anterior facet of the greater trochanter. Whether the labrum should be debrided or repaired, it is based on the size of the tear, the degree of detachment, and the quality of the labral tissue, aiming to preserve as much labral tissue possible and reestablish the normal seal effect of the labrum. Anatomic labral refixation can be accomplished with small diameter anchors. Labral eversion should be avoided, and depending on labral tissue quality, sutures should be placed either intrasubstance or circumferentially around the labrum (Fig. 10d).

After the central compartment is addressed and reevaluated for any residual sites of pathology, the hip is taken out of traction. If residual AIIS decompression is required, it is completed. The hip is flexed to evaluate for remaining subspine impingement. Should preoperative imaging and intraoperative findings document the presence of coexisting cam deformity, femoroplasty must follow in order to restore the normal offset of the head–neck junction and treat the intra-articular FAI (Fig. 11). Although femoroplasty can be performed effectively without capsulotomy, the T-capsulotomy leads to greater visualization of the peripheral compartment, allowing the surgeon to perform osteoplasty medially, laterally, and distally with greater ease up to the intertrochanteric line. Decompression of the anterior facet of the greater trochanter in certain cases of likely extra-articular impingement can be accomplished as well with this approach. Recent data from a CT-based, dynamic computer model showed that in straight flexion, impingement occurred most often on the inferior/medial region of the femoral head–neck junction along the medial synovial fold, whereas the average location of impingement on the acetabulum occurred at 1:30 (range, 12:30–2:15), corresponding to the area distal to the subspine region. T-capsulotomy may be required to address these "bump" locations. Fluoroscopy confirms at the end the adequate cam decompression (Fig. 11). Since these arthroscopic procedures are usually lengthy in time and require extensive soft-tissue dissection, it is critical to monitor the patient's abdominal pressure in order to observe for potential intra-abdominal extravasations of fluids, which may evolve to a serious complication. Finally, the T-capsulotomy is repaired in a side-to-side fashion with approximately 4–6 No. 2 nonabsorbable sutures depending upon the degree of inherent structural instability (static overload) or capsular laxity. Postoperative management should include 2–4 weeks of protected weight bearing with crutches and ROM exercises until protective muscle strength is regained. Strengthening and proprioception exercises may enhance the rehabilitation. No specific changes in postoperative rehabilitation are required when an AIIS decompression has been performed as part of an arthroscopic FAI corrective procedure. Anti-inflammatory medications appear to decrease the risk of HO [47], especially if aggressive subspine decompression has been performed. In the case of positive history for HO or intolerance to anti-inflammatories, one dose of radiation is recommended on postoperative day one. AP pelvis and lateral hip radiographs should be obtained at the 6-week follow-up visit and then at 1 year and 2 years after the operation to assess for potential development of HO, bone regrowth, or joint degradation.

Outcomes Following Arthroscopic AIIS/Subspine Decompression

The rationale of arthroscopic subspine decompression is supported by short-term outcomes series revealing improvement in hip function and ROM [6, 8, 30, 48]. Two studies are limited to small case series [6, 8] and have shown significant improvements in outcomes scores and hip flexion ROM, whereas a case report has shown similar results [48]. Larson et al. [6] introduced the concept of AIIS impingement and included 3 representative cases after arthroscopic subspine decompression, the mHHS improved from a mean of 76 points preoperatively to 94 points postoperatively with minimum 1-year follow-up. Hetsroni et al. [8] published the largest series of arthroscopic subspine decompression in 10 hips due to prior AIIS avulsion injury. At a mean of 14.7 months' follow-up, the mHHS improved from a mean of 64 points preoperatively to 98 points postoperatively; an improvement of a mean 18° in hip flexion range of motion was recorded as well. Matsuda and Calipusan [48] reported a case of arthroscopic AIIS decompression with 18 months' follow-up in a 13-year-old track athlete with a prior apophyseal avulsion injury that led to a resolution of symptoms. He returned to football with no symptoms with a terminal hip flexion of 120°, whereas his self-assessed nonarthritic hip score improved from 22 preoperatively to 98 postoperatively. Hapa et al. [30] recently published the results of the largest consecutive series to date in the literature. In this clinical series, 163 (150 patients) AIIS decompressions were performed for symptomatic subspine impingement. At a mean follow-up of 11.1 months, the mean mHHS significantly improved from 63.1 points preoperatively to 85.3 points. Short Form 12 scores improved significantly from a mean of 70.4 preoperatively to a mean of 81.3 postoperatively. Similarly, the mean pain score on a visual analog scale improved significantly from a mean of 4.9 preoperatively to a mean of 1.9 postoperatively. All published data highlight the low risk for postoperative hip flexion weakness and rectus femoris avulsion/rupture after such decompressions. Table 1 summarizes in detail the findings (number of patients, length of follow-up, and improvements in hip flexion ROM and in patient-reported scores) of the three published cases series.

Summary

Arthroscopic decompression of a symptomatic AIIS deformity is a reproducible and safe procedure that has shown to provide excellent outcomes at short-term follow-up. An arthroscopic approach may be advantageous in patients with

Table 1 Short-term outcomes of clinical series following arthroscopic subspine decompression for symptomatic AIIS impingement

	Number of patients/ hips	Follow-up in months, mean (min–max)	Preoperative hip flexion, mean (min–max)	Postoperative hip flexion, mean (min–max)	Preoperative hip and/or health survey and/or pain score, mean (min–max)	Postoperative hip and/or health survey and/or pain score, mean (min–max)
Larson et al. [6]	3/3	16 (12–18)	105° (100–110)	126.7° (125–130)	mHHS: 75.7 (74–79)	mHHS: 85.3 (37–100)
					VAS: 6.2 (4.8–8.0)	VAS: 1.1 (0–1.7)
Hetsroni et al. [8]	10/10	14.7 (6–26)	98.5° (90–110)	117° (110–130)	mHHS: 64.2 (41–96)	mHHS: 98.4 (96–100)
Hapa et al. [30]	150/163	11.1 (6–24)	N/R	N/R	mHHS: 63.1 (21–90)	mHHS: 85.3 (37–100)
					SF-12: 70.4 (34–93)	SF-12: 81.3 (31–99)
					VAS: 4.9 (0.1–8.6)	VAS: 1.9 (0–7.8)

mHHS modified Harris hip score, *SF-12* short form 12, *VAS* pain score on a visual analog scale, *N/R* not reported

mixed intra- and extra-articular causes of hip pain and dysfunction, because it enables the surgeon to address all pathologies with a single arthroscopic procedure. Preoperative planning to assess the morphology of the AIIS prominence with regard to location and required amount of decompression is of paramount importance. The use of fluoroscopy during surgery may prevent over- or under-resection of the AIIS distal or anterior extension, avoiding thus iatrogenic dysplasia or residual impingement, respectively. Long traction times should be avoided, and when extensive work in the central compartment is anticipated, the AIIS resection can be performed without traction. Because these procedures are lengthier and require extensive soft-tissue dissection, postoperative anti-inflammatory protocol is essential for the prevention of heterotopic bone formation. Adherence to these principles is associated with effectiveness and safety following arthroscopic subspine decompression.

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. doi:10.1097/01.blo.0000096804.78689.c2.
2. Rab GT. The geometry of slipped capital femoral epiphysis: implications for movement, impingement, and corrective osteotomy. J Pediatr Orthop. 1999;19:419–24.
3. Leunig M, Casillas MM, Hamlet M, Hersche O, Notzli H, Slongo T, Ganz R. Slipped capital femoral epiphysis: early mechanical damage to the acetabular cartilage by a prominent femoral metaphysis. Acta Orthop Scand. 2000;71:370–5. doi:10.1080/000164700317393367.
4. Toogood PA, Skalak A, Cooperman DR. Proximal femoral anatomy in the normal human population. Clin Orthop Relat Res. 2009;467:876–85. doi:10.1007/s11999-008-0473-3.
5. Siebenrock KA, Wahab KH, Werlen S, Kalhor M, Leunig M, Ganz R. Abnormal extension of the femoral head epiphysis as a cause of cam impingement. Clin Orthop Relat Res. 2004;418:54–60.
6. Larson CM, Kelly BT, Stone RM. Making a case for anterior inferior iliac spine/subspine hip impingement: three representative case reports and proposed concept. Arthroscopy. 2011;27:1732–7. doi:10.1016/j.arthro.2011.10.004.
7. Hetsroni I, Poultsides L, Bedi A, Larson CM, Kelly BT. Anterior inferior iliac spine morphology correlates with hip range of motion: a classification system and dynamic model. Clin Orthop Relat Res. 2013;471:2497–503. doi:10.1007/s11999-013-2847-4.
8. Hetsroni I, Larson CM, Dela Torre K, Zbeda RM, Magennis E, Kelly BT. Anterior inferior iliac spine deformity as an extra-articular source for hip impingement: a series of 10 patients treated with arthroscopic decompression. Arthroscopy. 2012;28:1644–53. doi:10.1016/j.arthro.2012.05.882.
9. Sink EL, Gralla J, Ryba A, Dayton M. Clinical presentation of femoroacetabular impingement in adolescents.

J Pediatr Orthop. 2008;28:806–11. doi:10.1097/BPO.0b013e31818e194f.
10. Anderson LA, Peters CL, Park BB, Stoddard GJ, Erickson JA, Crim JR. Acetabular cartilage delamination in femoroacetabular impingement. Risk factors and magnetic resonance imaging diagnosis. J Bone Joint Surg Am. 2009;91:305–13. doi:10.2106/JBJS.G.01198.
11. Dudda M, Albers C, Mamisch TC, Werlen S, Beck M. Do normal radiographs exclude asphericity of the femoral head-neck junction? Clin Orthop Relat Res. 2009;467:651–9. doi:10.1007/s11999-008-0617-5.
12. Cobb J, Logishetty K, Davda K, Iranpour F. Cams and pincer impingement are distinct, not mixed: the acetabular pathomorphology of femoroacetabular impingement. Clin Orthop Relat Res. 2010;468:2143–51. doi:10.1007/s11999-010-1347-z.
13. 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. doi:10.1302/0301-620X.87B7.15203.
14. Bedi A, Dolan M, Leunig M, Kelly BT. Static and dynamic mechanical causes of hip pain. Arthroscopy. 2011;27:235–51. doi:10.1016/j.arthro.2010.07.022.
15. Ito K, Minka II MA, Leunig M, Werlen S, Ganz R. Femoroacetabular impingement and the cam-effect. A MRI-based quantitative anatomical study of the femoral head-neck offset. J Bone Joint Surg Br. 2001;83:171–6.
16. Notzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. J Bone Joint Surg Br. 2002;84:556–60.
17. 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. doi:10.1007/s11999-009-0853-3.
18. Smith-Petersen MN. The classic: treatment of malum coxae senilis, old slipped upper femoral epiphysis, intrapelvic protrusion of the acetabulum, and coxa plana by means of acetabuloplasty. 1936. Clin Orthop Relat Res. 2009;467:608–15. doi:10.1007/s11999-008-0670-0.
19. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. A cause of hip pain. J Bone Joint Surg Br. 1999;81:281–8.
20. Siebenrock KA, Schoeniger R, Ganz R. Anterior femoro-acetabular impingement due to acetabular retroversion. Treatment with periacetabular osteotomy. J Bone Joint Surg Am. 2003;85-A:278–86.
21. Jamali AA, Mladenov K, Meyer DC, Martinez A, Beck M, Ganz R, Leunig M. Anteroposterior pelvic radiographs to assess acetabular retroversion: high validity of the “cross-over-sign”. J Orthop Res. 2007;25:758–65. doi:10.1002/jor.20380.
22. Fujii M, Nakashima Y, Yamamoto T, Mawatari T, Motomura G, Matsushita A, Matsuda S, Jingushi S, Iwamoto Y. Acetabular retroversion in developmental dysplasia of the hip. J Bone Joint Surg Am. 2010;92:895–903. doi:10.2106/JBJS.I.00046.
23. Eijer H, Podeszwa DA, Ganz R, Leunig M. Evaluation and treatment of young adults with femoro-acetabular impingement secondary to Perthes’ disease. Hip Int. 2006;16:273–80.
24. Rajasekhar C, Kumar KS, Bhamra MS. Avulsion fractures of the anterior inferior iliac spine: the case for surgical intervention. Int Orthop. 2001;24:364–5.
25. Rossi F, Dragoni S. Acute avulsion fractures of the pelvis in adolescent competitive athletes: prevalence, location and sports distribution of 203 cases collected. Skeletal Radiol. 2001;30:127–31.
26. Mader TJ. Avulsion of the rectus femoris tendon: an unusual type of pelvic fracture. Pediatr Emerg Care. 1990;6:198–9.
27. Reina N, Accadbled F, de Gauzy JS. Anterior inferior iliac spine avulsion fracture: a case report in soccer playing adolescent twins. J Pediatr Orthop B. 2010;19:158–60. doi:10.1097/BPB.0b013e32833399a4.
28. Gomez JE. Bilateral anterior inferior iliac spine avulsion fractures. Med Sci Sports Exerc. 1996;28:161–4.
29. Gray H. Muscles and fasciae. In: Pickering T, Howden R, editors. Gray’s anatomy. New York: Crown; 1977. p. 415–31.
30. Hapa O, Bedi A, Gursan O, Akar MS, Guvencer M, Havitcioglu H, Larson CM. Anatomic footprint of the direct head of the rectus femoris origin: cadaveric study and clinical series of hips after arthroscopic anterior inferior iliac spine/subspine decompression. Arthroscopy. 2013;29:1932–40. doi:10.1016/j.arthro.2013.08.023.
31. Draovitch P, Edelstein J, Kelly BT. The layer concept: utilization in determining the pain generators, pathology and how structure determines treatment. Curr Rev Musculoskelet Med. 2012;5:1–8. doi:10.1007/s12178-011-9105-8.
32. Poultsides LA, Bedi A, Kelly BT. An algorithmic approach to mechanical hip pain. HSS J. 2012;8(3):213–24.
33. Skendzel JG, Weber AE, Ross JR, Larson CM, Leunig M, Kelly BT, Bedi A. The approach to the evaluation and surgical treatment of mechanical hip pain in the young patient: AAOS exhibit selection. J Bone Joint Surg Am. 2013;95:e1331–16. doi:10.2106/JBJS.L.01611.
34. Blankenbaker DG, Tuite MJ. Non-femoroacetabular impingement. Semin Musculoskelet Radiol. 2013;17:279–85. doi:10.1055/s-0033-1348094.
35. Notzli HP, Wyss TF, Stoecklin CH, Schmid MR, Treiber K, Hodler J. The contour of the femoral head-neck junction as a predictor for the risk of anterior impingement. J Bone Joint Surg Br. 2002;84:556–60.
36. Pan H, Kawanabe K, Akiyama H, Goto K, Onishi E, Nakamura T. Operative treatment of hip impingement caused by hypertrophy of the anterior inferior iliac spine. J Bone Joint Surg Br. 2008;90:677–9. doi:10.1302/0301-620X.90B5.20005.

37. Kivlan BR, Martin RL, Sekiya JK. Response to diagnostic injection in patients with femoroacetabular impingement, labral tears, chondral lesions, and extra-articular pathology. Arthroscopy. 2011;27:619–27. doi:10.1016/j.arthro.2010.12.009.
38. Amar E, Druckmann I, Flusser G, Safran MR, Salai M, Rath E. The anterior inferior iliac spine: size, position, and location. An anthropometric and sex survey. Arthroscopy. 2013;29:874–81. doi:10.1016/j.arthro.2013.01.023.
39. Leunig M, Beck M, Kalhor M, Kim YJ, Werlen S, Ganz R. Fibrocystic changes at anterosuperior femoral neck: prevalence in hips with femoroacetabular impingement. Radiology. 2005;236:237–46. doi:10.1148/radiol.2361040140.
40. Milone MT, Bedi A, Poultsides L, Magennis E, Byrd JW, Larson CM, Kelly BT. Novel CT-based three-dimensional software improves the characterization of cam morphology. Clin Orthop Relat Res. 2013;471:2484–91. doi:10.1007/s11999-013-2809-x.
41. Bedi A, Thompson M, Uliana C, Magennis E, Kelly BT. Assessment of range of motion and contact zones with commonly performed physical exam manoeuvers for femoroacetabular impingement (FAI): what do these tests mean? Hip Int. 2013. doi:10.5301/hipint.5000060.
42. Robertson WJ, Kelly BT. The safe zone for hip arthroscopy: a cadaveric assessment of central, peripheral, and lateral compartment portal placement. Arthroscopy. 2008;24:1019–26. doi:10.1016/j.arthro.2008.05.008.
43. Matsuda DK. Acute iatrogenic dislocation following hip impingement arthroscopic surgery. Arthroscopy. 2009;25:400–4. doi:10.1016/j.arthro.2008.12.011.
44. Ranawat AS, McClincy M, Sekiya JK. Anterior dislocation of the hip after arthroscopy in a patient with capsular laxity of the hip. A case report. J Bone Joint Surg Am. 2009;91:192–7. doi:10.2106/JBJS.G.01367.
45. Konan S, Rhee SJ, Haddad FS. Hip arthroscopy: analysis of a single surgeon's learning experience. J Bone Joint Surg Am. 2011;93 Suppl 2:52–6. doi:10.2106/JBJS.J.01587.
46. Zaltz I, Kelly BT, Hetsroni I, Bedi A. The crossover sign overestimates acetabular retroversion. Clin Orthop Relat Res. 2013;471:2463–70. doi:10.1007/s11999-012-2689-5.
47. Bedi A, Zbeda RM, Bueno VF, Downie B, Dolan M, Kelly BT. The incidence of heterotopic ossification after hip arthroscopy. Am J Sports Med. 2012;40:854–63. doi:10.1177/0363546511434285.
48. Matsuda DK, Calipusan CP. Adolescent femoroacetabular impingement from malunion of the anteroinferior iliac spine apophysis treated with arthroscopic spinoplasty. Orthopedics. 2012;35:e460–3. doi:10.3928/01477447-20120222-44.