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Mini Symposium

MINI SYMPOSIUM

Endoscopic hip osteotomies: less invasive approaches to peri-acetabular, proximal femoral and pubic symphyseal procedures

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ABSTRACT

Beyond the recent expansion of extra-articular hip arthroscopy into the peri-trochanteric and subgluteal space, this instructional course lecture introduces three innovative procedures: endoscopy-assisted periacetabular osteotomy, closed derotational proximal femoral osteotomy and endoscopic pubic symphysectomy. Supportive rationale, evolving indications, key surgical techniques and emerging outcomes are presented for these innovative less invasive procedures.

INTRODUCTION

Extra-articular hip arthroscopy has been recently used for the treatment of various conditions such as subspine impingement [1], gluteus medius/minimus tears [2], ischiofemoral impingement [3], sciatic entrapment [4] and proximal hamstring repair [5]. Many of these procedures involve the peritrochanteric or subgluteal space. As potential indications for extra-articular hip arthroscopy expand, some of the major knowledge gaps include minimally invasive approaches for the treatment of hip dysplasia, acetabular retroversion with posterior insufficiency, severe femoral anteversion and retroversion, and osteitis pubis (arguably the most common form of athletic pubalgia). In general, all of these procedures offer less invasive approaches to more established open surgeries (i.e. open peri-acetabular osteotomy (PAO), open proximal femoral osteotomy (PFO), open pubic symphysis curettage), thereby enabling potential outpatient or short-stay hospitalization, quicker rehabilitation, less blood loss and improved cosmesis. These are advanced endoscopic surgical procedures meriting familiarity with the surgical anatomy and significant experience with hip arthroscopy. The indications for these procedures are the same as for their open equivalent surgeries and are described in each corresponding section, as are the complications. The purpose of this instructional course lecture is to introduce endoscopy-assisted PAO (eaPAO), closed derotational PFO (cPFO) and endoscopic pubic symphysectomy (ePS) as potential options for the less invasive treatment of these conditions.

ENDOSCOPY-ASSISTED PERI-ACETABULAR OSTEOTOMY eaPAO has significant potential to improve outcomes and safety in patients with dysplasia (retroverting PAO) or acetabular retroversion with posterior insufficiency (anteverting PAO). PAO is associated with a significant complication rate [6, 7] and endoscopic visualization of the posterior column and ischial osteotomies may reduce the incidence of iatrogenic direct sciatic nerve injury (including neurotmesis), intra-articular fracture or osteotomy, posterior column fracture or discontinuity and acetabular osteonecrosis. Although an endoscopic triple osteotomy has been developed [8], we endeavor to enhance the Bernese PAO which preserves

posterior column functional integrity, thereby facilitating early ambulation with minimal osteosynthesis of the reoriented acetabular fragment. Development of this procedure is at the cadaveric stage and uses a mini-open [9–11] rather than standard ilioinguinal approach.

Concurrent arthroscopy (in contrast to endoscopy) can diagnose and treat a majority of central compartment pathology (e.g. chondral flaps, labral tears) in dysplasia [12, 13] and may prevent unwarranted PAO in cases of worse than anticipated chondral injury or osteoarthosis via staged or immediate total hip arthroplasty. Peripheral compartment arthroscopy permits assessment of dynamic interaction between the reoriented acetabular rim and the proximal femur, often after concurrent arthroscopic femoroplasty, as many patients with dysplasia (and retroversion) have associated cam femoroacetabular impingement (FAI). This may improve the accuracy of 3D intra-operative acetabular reorientation (minimizing under- or over-correction [14]) and facilitate confirmation of sufficient stabilization (typically with percutaneous screw fixation). Perhaps most significant, patients with Developmental dysplasia of the hip (DDH) or acetabular retroversion with posterior insufficiency that desire hip arthroscopy as a minimally invasive surgery may now have a more biomechanically appropriate yet less invasive option (eaPAO), that may reduce the number of failed hip arthroscopies [15, 16]. Furthermore, we envision eaPAO as a logical progression toward fully endoscopic PAO (ePAO).

SURGICAL PROCEDURE

Supine hip arthroscopy under general anesthesia is performed as an initial diagnostic and therapeutic step, followed by mini-open eaPAO (Fig. 1) and concluding with arthroscopic dynamic testing. In the supine position, central compartment arthroscopy is performed with a 70° arthroscope. Any intra-articular pathology is either treated or a determination may be made that the severity and/or extent of chondral damage exceeds that that can reasonably expected to benefit from acetabular reorientation, perhaps opting for hip arthroplasty. Arthroscopic femoroplasty for coexisting cam FAI may be performed at this stage.

A mini-open modified Heuter approach permits muscle-sparing dissection of the interval between Sartorius and tensor fascia lata (TFL). Avoiding the lateral femoral cutaneous nerve, the fascia lata is incised in line with the skin incision followed by blunt dissection around the medial aspect of the TFL within its incised aponeurotic sheath. Medial retraction of the sartorius and deeper rectus femoris reveals the reflected head of the rectus femoris as it overlays the hip capsule.

Ischial osteotomy is performed with a straight osteotome positioned in the infracotyloid fossa. During this osteotomy, the sharp tip of the osteotome is endoscopically visualized with a 70° standard length arthroscope from the anterolateral portal (Fig. 2). Endoscopy of the posterior peritrochanteric region (subgluteal space) without any hip distraction enables visualization, neurolysis and mobilization of the sciatic nerve, which may be followed proximally and distally with blunt dissection via a switching stick from the posterolateral portal. If more proximal neurolysis or mobilization is required, endoscopic ligation and transection of the crossing vessels from the inferior gluteal artery may be performed. Overzealous fluid ingress or excessive radiofrequency (RF) ablation are avoided. Monopolar RF with intermittent activation times of <10 s in a setting of sufficient fluid flow permits safe soft tissue dissection [17]. If endoscopy reveals the osteotome tip

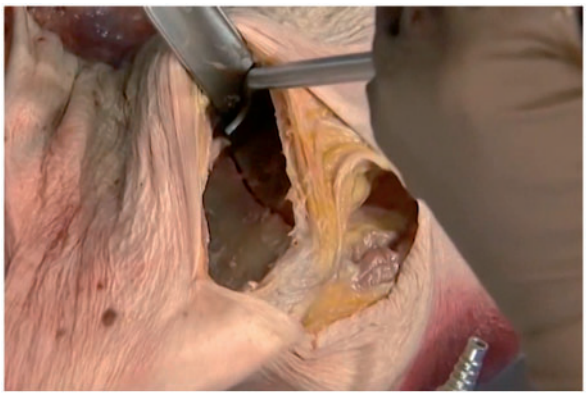

Fig. 1. External photograph of eaPAO during posterior column osteotomy through Hueter approach. Note the completed iliac osteotomy and a portion of the arthroscope (lower right) which provides endoscopic guidance for the posterior column osteotomy.

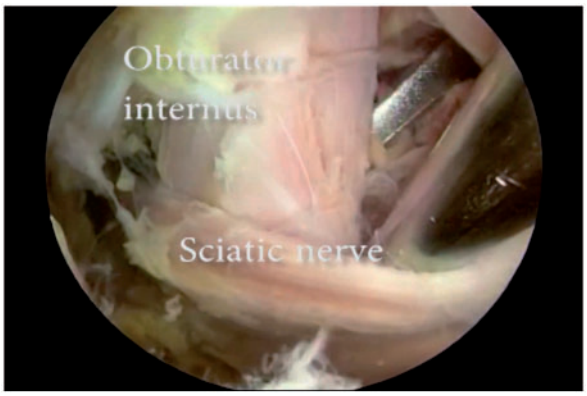

Fig. 2. Supine endoscopic view from anterolateral portal of the right sub-gluteal space of cadaveric specimen during ischial osteotomy during eaPAO. Note the sharp tip of the osteotome in proximity to the gently retracted sciatic nerve.

approaching the sciatic nerve, the ostetome may be redirected and/or the sciatic nerve may be gently retracted.

The pubic and iliac osteotomies are then performed, followed by the posterior column osteotomy made with endoscopic assistance. Without changing portals, arthroscopic inflow may be restored to permit clear visualization of the osteotome. The visualized sciatic nerve may again be gently retracted to avoid inadvertent injury (Fig. 3). Sometimes osteoclasis of a small bony bridge is performed between adjacent ends of the ischial and posterior column osteotomies permitting mobilization of the acetabular fragment. The pubic osteotomy is made close to the acetabulum to avoid bony obstruction to desired medial acetabular translation (shown fluoroscopically as a medial shift of the teardrop). During the pubic or posterior column cuts, inadvertent intra-articular violation may occur. Arthroscopic visualization of the central compartment under moderate hip traction permits detection/prevention of this complication. Traction is then released.

Positioning of the acetabular fragment is facilitated with a percutaneous Schanz screw. Desired acetabular reorientation is confirmed via fluoroscopy and/or intra-operative AP pelvic radiograph followed by percutaneous screw fixation. Care is taken to avoid inadvertent retroversion from over-correction, under-correction or insufficient medialization of the acetabular fragment. Peripheral compartment arthroscopy permits endoscopic dynamic examination of the hip. Repositioning of the acetabular fragment may be performed if indicated or small regions of anterior pincer FAI may be seamlessly treated with rim trimming. The fascia lata is closed, followed by subcutaneous and skin closure. We have no outcomes on this evolving procedure as it has only been performed on cadaveric specimens to date.

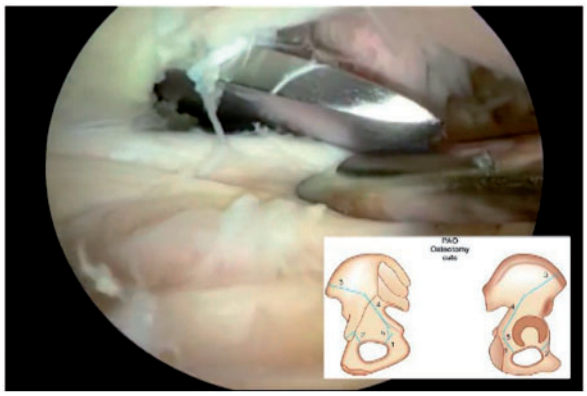

Fig. 3. Supine endoscopic view from anterolateral portal during posterior column osteotomy demonstrating the sharp tip of the osteotome in proximity to the sciatic nerve. Sciatic nerve retraction is being performed with a switching stick via the posterolateral portal.

CLOSED PROXIMAL FEMORAL OSTEOTOMY

Proximal femoral osteotomy has been useful in the treatment of axial (derotation) and longitudinal deformities (varus/valgus, flexion/extension). 'Closed' osteotomy using an intramedullary saw permits derotation osteotomies for severe proximal femoral retroversion (which may cause cam FAI that persists despite femoroplasty [18]) and severe anteversion (which may cause anterior hip instability or posterior FAI.). Internal fixation via intramedullary locked nailing provides a load-sharing device for early weight-bearing. Moreover, recent work suggests that there is potential for some degree of angulatory correction. Adjunctive hip arthroscopy aids pre- and post-osteotomy assessment of altered hip dynamics while permitting detection/treatment of intra-articular pathology.

SURGICAL TECHNIQUE

The patient is placed on a fracture table in the supine position. Hip arthroscopy under general anesthesia is performed via an anterolateral viewing portal with a 70° arthroscope and a modified mid-anterior working portal [19]. Under hip distraction, diagnostic and therapeutic hip arthroscopy is performed, followed by arthroscopic dynamic testing to assess the amount of secondary cam FAI from pathologic femoral retroversion (Fig. 4). A seamless progression to derotational osteotomy is performed without a change in setup or redraping.

A fluoroscopic C-arm device is positioned between the legs so as to enable anteroposterior and lateral projections of the entire operative femur. Parallel lateral-based Steinmann pins are placed on each side of the proposed osteotomy. The proximal pin is placed through the anterolateral portal into the anterior aspect of the greater trochanter (to avoid

Fig. 4. Supine arthroscopic image of left hip immediately prior to cPFO confirming ongoing cam impingement on arthroscopic anterior impingement testing despite significant previous femoroplasty.

intramedullary nail obstruction) and the distal pin in the transcondylar region. The anteroposterior location of the latter is not critical because the rod does not extend to this level.

A 3-cm vertical incision is made proximal to the greater trochanter with subsequent dissection to its apex. Apical trochanteric pin placement and proximal femoral entry are established under bi-plane fluoroscopic guidance. An intramedullary saw (Winquist saw; Biomet, Warsaw, IN) is selected to match the anticipated maximal external diameter of cortical bone at a level 5–6 cm distal to the lesser trochanter. With the saw blade retracted behind the protective cam-shaped tip, antegrade intramedullary insertion is achieved. Once confirmed in the desired intramedullary position, the saw blade is progressively protracted by clockwise rotation of a proximal-based external dial and axial saw rotation performed in incremental fashion until the closed transverse osteotomy is completed (Fig. 5). Care should be taken to ensure a 'clean' transverse osteotomy without significant cortical spikes that might impede desired derotation or bony apposition. The saw blade is then fully retracted behind the protective cam by continuing to dial in the same clockwise direction (until the dial reads '0') and extracted from the femoral canal.

A reamed intramedullary rod is then partially inserted across the osteotomy site and controlled internal rotation of the distal segment is performed. (In the case of excessive femoral anteversion, external derotation is performed.) To assess sufficient derotation, divergence of the parallel-placed pins is viewed from a distal-based axial perspective. An angular guide (Blade plate guide; Synthes) is used to measure the relative angular degree of rotation (Fig. 6). Once desired derotation is achieved, the intramedullary rod is fully inserted and percutaneous proximal screw placement is performed under fluoroscopic guidance. Distal interlocked screw fixation is performed once desired axial alignment and bony apposition are confirmed.

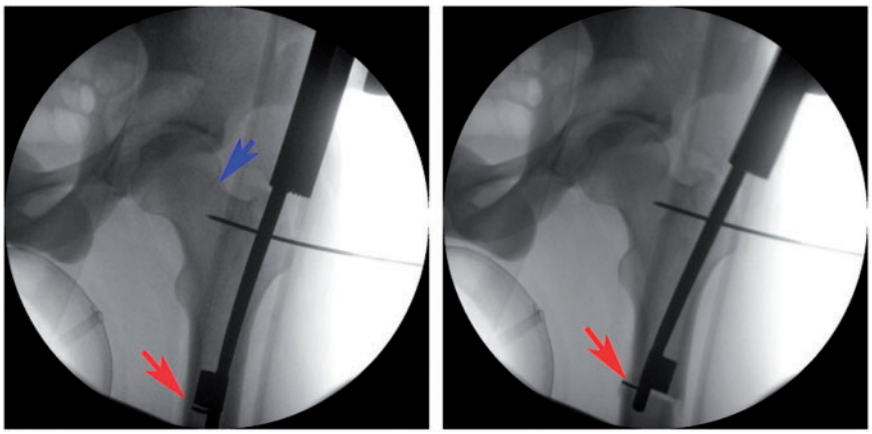

Fig. 5. Fluoroscopic images of intramedullary saw (red arrow) before (left) and after (right) saw blade deployment and completion of transverse subtrochaneric osteotomy. The blue arrow demonstrates a region of arthroscopic femoroplasty from a prior surgery.

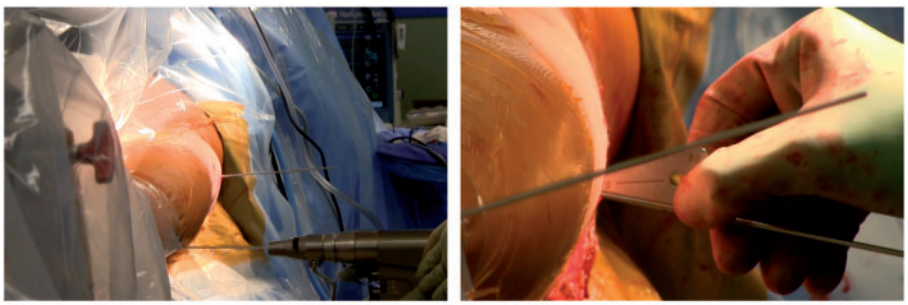

Fig. 6. Photograph from axial perspective during derotational correction of severe retroversion deformity over proximally fixated femoral rod. Photograph (left) during derotation with 30° internal rotation of distal segment using an AO angle guide referencing off of initial parallel guide pins (right).

Repeat hip arthroscopy is performed to confirm impingement-free internal rotation to 30° with flexion–adduction–internal rotation testing. Once satisfied with the rotational correction of the femoral deformity, foot alignment in both hip and knee extension, as well as hip and knee flexion are checked to ensure the absence of any significant compensatory tibial rotational deformity.

Surgical outcomes are limited to two case reports. Severe bilateral retrotorsion in a young man caused ongoing symptomatic cam FAI despite previous arthroscopic surgeries with substantial femoroplasties. He underwent staged proximal femoral derotational osteotomies using the aforementioned technique, was discharged home weight-bearing as tolerated on crutches after overnight hospitalization and demonstrated radiographic union at 3 months with improved gait (pre-operative out-toeing, post-operative normal foot progression) and symptoms at 12 and 15 months (Fig. 7) [18]. Another case report demonstrated similar successful findings using an expandable nail [20].

ENDOSCOPIC PUBIC SYMPHYSECTOMY

Athletic osteitis pubis (OP) is one of the more common causes of athletic pubalgia that has an often successful but prolonged conservative treatment course and 5–10% failure rate [21]. Of several surgical options including wedge resection, arthrodesis, extraperitoneal retropubic synthetic mesh placement and pubic symphyseal curettage, no one procedure has been established as producing better outcomes. Open curettage has been shown to be effective in athletes and is arguably less invasive than some of the other surgeries [21, 22]. A mini-open curettage has recently been introduced, but is done via a 5–7 cm Pfannenstiel incision [23].

OP is often associated with FAI in active patients. Indeed, the constrained range of motion in the hip with FAI is thought to cause increased transfer stress to the pubic symphysis [24]. Although treatment of co-afflicted patients may be done with either FAI or OP surgery in patients that fail conservative measures, surgical treatment of both conditions offers the best outcomes [25]. ePS is an attractive alternative to open or mini-open pubic symphyseal curettage that nicely complements athletes that undergo concurrent arthroscopic surgery for unilateral or bilateral FAI [26]. Moreover, more patients with athletic OP may opt for this less invasive outpatient procedure rather than suffer with a typically prolonged conservative treatment course.

Surgical Technique

Following arthroscopic or mini-open surgery for FAI (e.g. acetabuloplasty, labral refixation and femoroplasty) and after redraping and sterile preparation of the pubic region, outpatient dual-portal endoscopic surgery is performed in the supine lithotomy position under hypotensive general anesthesia. An indwelling urethral catheter is used not only because of the longer cumulative operative time needed for all procedures but also for bladder decompression to minimize risk of iatrogenic damage. Initial anterior–posterior fluoroscopic imaging may be used to confirm pubic symphyseal location. Two midline portals are made (Fig. 8): one 2 cm proximal to the palpable superior border of the pubic symphysis (suprapubic portal) and one directly anterior to the mid-level of the pubic symphysis (anterior portal). The anterior and superior aspects of the pubic symphysis are endoscopically visualized with a 30° arthroscope after initial removal of overlying bursal tissue. After

Fig. 7. Post-operative radiographs following cPFO of right femur at 15 months and left femur at 12 months.

demarcating the area of planned resection on the anterior surface of the pubic symphysis with an RF probe and meticulous hemostasis enabling low arthroscopic pump pressures at or below 40 mm Hg, pubic symphysectomy is performed with a 4 mm round burr (Fig. 9). If present, a posterosuperior bone spur is resected. Then, burr resection proceeds from anterior (superficial) to posterior (deep) under endoscopic visualization with intermittent fluoroscopic guidance. Removal of the burr sheath aids access to the deeper (posterior) pubic symphysis. A retractable sheath burr (Retractable sheath hip burr, Smith and Nephew, Andover, MA) is also an option and may aid visualization by preserving controlled fluid outflow via a retracted but retained sheath. Endoscopic resection of the anterior capsule, pubic symphyseal fibrocartilage and subchondral end-plates is performed while preserving the posterior and thick arcuate (inferior) ligaments. The former prevents inadvertent bladder injury while the latter stabilizes the pubic symphysis. The burr is interchanged between portals to facilitate pubic symphysectomy. Final posteroinferior resection is done with the burr in the suprapubic portal, optimizing burr access to this region (Fig. 10). The completed resection gap is approximately 8–10 mm along the entire pubic symphysis. Associated adductor longus tendinopathy [27] or tears and even a torn rectus abdominus attachment may be treated via this approach. The indwelling bladder catheter is removed following routine portal closure.

These procedures are performed as outpatient surgery. Post-operative rehabilitation includes initial weight-bearing as tolerated with two crutches (1–2 weeks) and early exercise cycling with minimal resistance. In contrast to our standard post-operative FAI surgery protocol (i.e. cycling on post-operative day 1), patients undergoing endoscopic pubic symphysectomy typically are able to begin this within the first week. Gradual advancement to running is permitted at approximately 3 post-operative months and

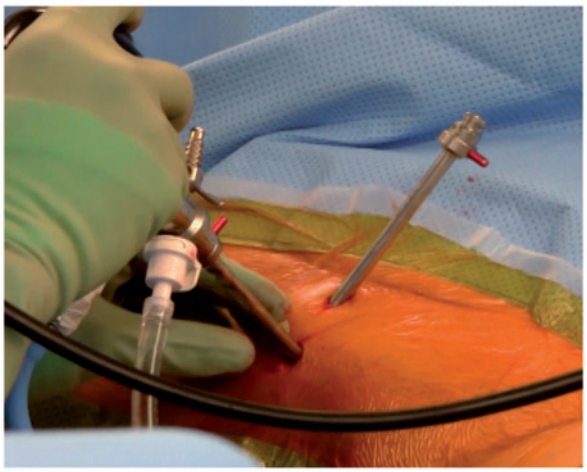

Fig. 8. Portals for ePS with patient in supine lithotomy position. Note the anterior (with inserted arthroscope) and suprapubic portals.

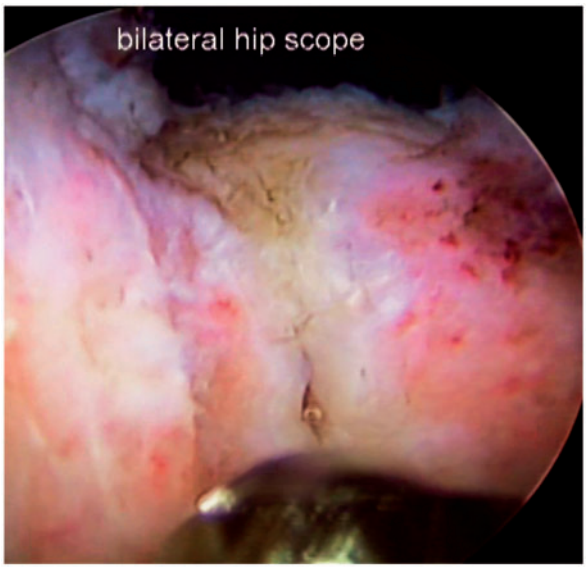

Fig. 9. Supine endoscopic view of pubic symphysis during ePS. An unhooded or retractable sheath burr may facilitate resection of the deeper (posterior) fibrocartilage and hyaline endplates without violating the posterior or inferior capsuloligamentous structures.

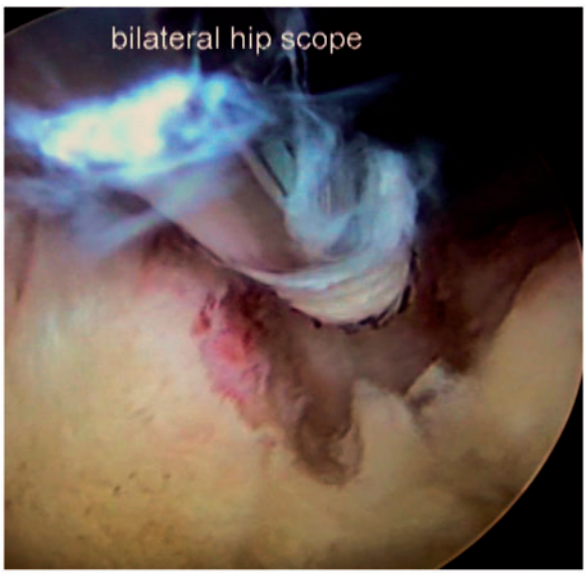

Fig. 10. The suprapubic portal enables burr access to the posteroinferior pubic symphysis to complete the procedure.

return to sport at 5 months, realizing that the typically concurrent unilateral or bilateral FAI surgery may exert rate-limiting influence.

In a multicenter case series, we report encouraging early outcomes in seven patients with symptomatic FAI and OP that underwent concurrent FAI surgery and ePS [28]. Although one patient underwent pubic symphysis arthrodesis for unresolved pain without radiographic instability, overall clinical improvement was demonstrated via visual analogue scale for pain and non-arthritic hip score. Complications were limited to two cases of scrotal swelling that spontaneously resolved.

CONCLUSIONS

Endoscopy-assisted peri-acetabular osteotomy has potential to improve safety and outcomes for patients with dysplasia or acetabular retroversion with posterior insufficiency. Closed derotational femoral osteotomy with adjuctive hip arthroscopy may offer a less invasive alternative to the treatment of severe femoral anteversion and retroversion. Endoscopic pubic symphysectomy is emerging as a treatment option for recalcitrant osteitis pubis.

CONFLICT OF INTEREST STATEMENT

D.K.M. is a consultant for Biomet. He received royalties from Smith and Nephew, Biomet, ArthroCare.

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