Introduction

The utilization of hip arthroscopy to address intra-articular and extra-articular hip pathology has exploded since the early 21st century, with an increase of over 400% in the United States (1), and similar or greater increases in Europe (2) and Asia (3). Naturally, new issues continue to be identified, studied, and addressed. An important aspect of hip arthroscopy is the management of patients with residual or recurrent symptoms following index hip arthroscopy. Data on revision hip arthroscopy is increasingly prevalent in recent literature, including two recent systematic reviews on the topic (4,5). This review discusses the prevalence, etiology, clinical approach, pre-operative planning process, intra-operative strategies, and patient counselling as they relate to revision hip arthroscopy.

Epidemiology & etiology

The rates of revision hip arthroscopy have been reported to be 2–6% (6,7). The reasons for revision hip arthroscopy are multifactorial and continue to be studied, understood, and defined. In broad terms, they can be categorized into intra-articular and extra-articular pathologies. Equally challenging is the difficulty differentiating non-hip related etiologies that can often refer pain or masquerade as hip pathology.
**Intra-articular etiologies**

Intra-articular etiologies of revision hip arthroscopy include bony under- or over-resection, capsular instability, osteochondral lesions, and osteoarthrosis. Bony under-resection has been consistently reported as one of the most common indications for revision hip arthroscopy, responsible for 40–64% of revisions (4,8,9). In fact, Philippon et al. (2007) found that 97.3% of patients undergoing revision hip arthroscopy had femoroacetabular impingement (FAI) morphology that was either inadequately addressed or not addressed at all in the index surgery (10). Despite the significant increase in awareness and literature regarding FAI since the publication of that study, a recent cross-sectional study found residual FAI rates of 74–86% in patients requiring revision hip arthroscopy (11). Instability following hip arthroscopy is a controversial entity. There are undoubtedly some reported cases of catastrophic failure secondary to gross instability after hip arthroscopy; a recent systematic review analyzed nine such cases (12). However, another recent systematic review on the topic found a lack of evidence directly linking closure to the risk of post-operative instability (13). The concept of “micro-instability” is relatively new and poorly defined with no objective criteria (14). A retrospective study of 25 revision hip arthroscopies found 9 patients having repeat surgery for reasons other than residual FAI (alpha angle >55°; CEA >40°). Pre-operative MRA found capsular defects in 7 patients (78%) and all patients had an abnormal capsule at the time of revision surgery with two patients having gross capsular deficiency with exposed muscle visualized from the central compartment. Interestingly, all patients were young, active females which may suggest a particular subgroup that is more prone to developing symptoms of instability (15). Bony over-resection is an even rarer complication of hip arthroscopy, but can result in the loss of the “suction seal” mechanism of the labrum, leading to a presentation similar to that of micro-instability (16). Other etiologies for revision hip arthroscopy include acetabular dysplasia, psoas tendonitis, and osteochondral lesions (11).

**Extra-articular etiologies**

Data on heterotopic ossification (HO) post-arthroscopy is scarce, but some risk factors have been identified, including male gender, extensive rim trimming, and anchor placement (17,18). Small to medium HO lesions are usually asymptomatic, and HO does not necessarily result in a poorer functional outcome (19). Thus, pain and/or functional limitation should not be automatically attributed to HO unless there are significant radiographic findings (usually Brooker III or IV) along with mechanical limitation on range of motion (20,21). A recent randomized control led study of 106 patients found that rates of HO in patients who received post-operative naproxen was 4% compared to 46% in the placebo group (RR =0.09, CI =0.02 to 0.38, P<0.001). Although enrolment was terminated early due to convincing treatment effect, the study did not report clinical outcomes, and the potential adverse effects of prophylactic non-steroidal anti-inflammatories need to be further evaluated (22).

A number of other causes of hip pain present similarly to, and can occur concurrently with FAI, and should be evaluated with physical examination. Most commonly, these include adductor-related pathology, snapping hip syndrome, “athletic pubalgia”, and subspine impingement. Adductor strains and tendonitis can present as hip or groin pain, particularly in athletes (23). Snapping hip syndrome is an audible snapping sound, with or without pain, that is most commonly due to the iliobibial band or glutaeus maximus tendon snapping over the greater trochanter during extension (24). Subspine impingement is the result of repeated impingement between the head-neck junction and a hypertrophic anterior inferior iliac spine (AIIS).

**Etiologies unrelated to the hip and surrounding structures**

A comprehensive review of extra-articular etiologies of persistent and recurrent pain after hip arthroscopy is beyond the scope of this review, but these are important considerations before proceeding with revision hip arthroscopy. Spinal pathology is an important cause of referred hip pain, and should be considered at the very least, and investigated if appropriate (25). What further confuses the issue is the spine-hip syndrome, where often there is co-existing pathology of FAI and degenerative disc disease of the lumbar spine (26). Greater trochanteric bursitis is another cause of hip pain that can be managed non-operatively and should be considered as a potential etiology (27).

**Other etiologies**

Adherence to post-operative rehabilitation is an important component of positive outcomes following orthopaedic surgery (28). Thus, inadequate rehabilitation can be a potential cause of failure of the index surgery, and should
be discussed with the patient if revision surgery is being considered. Missed concurrent diagnoses (e.g., subspine impingement, adductor pathology, etc.) are also an important potential etiology for revision hip arthroscopy— as outlined above, the hip is a complex joint with many surrounding and nearby structures, and the presence of a given diagnosis does not necessarily exclude the presence of all others.

**Clinical presentation**

**History**

A precise history is crucial to correctly identifying the cause of failure. It is important to delineate between residual (i.e., lack of improvement) and recurrent (i.e., period of relief followed by re-occurrence of symptoms) symptoms following index surgery. Several authors have recommended follow-up for at least two years, given that the timeline between index and revision surgery is most commonly between two and three years (6,29,30).

The most common sites for pain in FAI are the groin and the lateral hip (31). Classically, patients may exhibit the “C-sign”, whereby the patient points to the anterolateral aspect of the hip with the thumb just above the greater trochanter and the index finger anteriorly (32). This pattern of pain points to an intra-articular etiology, and a further, careful history can help to differentiate between impingement and degenerative causes. As degenerative changes progress, pain becomes more constant, whereas pain related to more focal and acute causes tends to present as sharp, intermittent, related to specific activities and positions, and accompanied by mechanical symptoms such as clicking, locking, or catching (33). Psoas tendonitis is a painful condition that often presents with snapping and/or sharp pain, particularly during deep flexion activities (34). Over 80% of patients with an eventual diagnosis of FAI describe anterior groin pain, even when multiple painful regions are involved (31,35). Thus, in patients presenting with post-operative pain that does not involve the groin at all, a careful diagnostic workup is indicated to rule out extra-articular etiologies.

**Physical examination**

As in any clinical scenario, a careful physical examination is extremely important as it can help to distinguish between intra-articular and extra-articular pathologies. According to Byrd et al., a full clinical examination has a 98% sensitivity for identifying intra-articular pathology (36). A complete physical examination of the hip should be conducted including gait analysis, stance, neurovascular status, palpation, range of motion, and special tests. Viswanath et al. provide a detailed, evidence-based approach to physical examination of the hip, the details of which are beyond the scope of this review (37). Specific examination manoeuvres relevant to revision hip arthroscopy are highlighted in this section.

Muscular weakness is common in the acute post-operative period, but patients should expect to regain or exceed their pre-operative strength by six months post-operatively (38). The exception to this is hip flexor strength, which may remain weaker even 2.5 years post-arthroscopy (38). In addition, the index arthroscopic surgery may have included iliopsoas lengthening or tenotomy. Weakness and/or pain on resisted hip flexion compared to the contralateral side suggest pathology involving the iliopsoas muscle, though the diagnostic utility is unclear, with specificity reported between 0.38 and 1.0, and sensitivity of 0.06–0.75 (39). Positive Trendelenburg sign suggests abductor muscle weakness (40). The anterior and posterior apprehension tests, which are conceptually similar to apprehension testing for the shoulder, can be used to assess for micro-instability. The anterior apprehension test is performed with the patient supine, with the buttocks at the edge of the table. The affected extremity is taken into extension and external rotation. The posterior apprehension test is performed with the affected hip flexed to 90°, adducted, and internally rotated. A posteriorly directed force is then applied. In both tests, a positive test reproduces pain and/or feelings of instability (14).

Non-FAI related hip pathologies that also present with hip and/or groin symptoms should also be evaluated. Adductor tendonitis and strains can present with tenderness over the adductor tendon and/or muscle belly, and pain on passive abduction and resisted adduction (23). Snapping hip can be readily observed during physical examination. For confirmation, the patient can be placed in the lateral decubitus position on the unaffected hip. The affected hip is then taken into extension while pressure is placed on the greater trochanter to prevent snapping of the tendon(s) (24). Tenderness to palpation over the AIIS is suggestive of subspine impingement (41).

Multiple special tests have demonstrated high sensitivity in identifying intra-articular hip pathology, including labral tears and FAI. These include the anterior impingement...
test (Sensitivity =0.59–1.0), flexion-abduction-external rotation (FABER) test (0.41–0.97), the Fitzgerald test (0.96), the hip quadrant test (0.88–1.0), the Thomas test (0.89), and the internal rotation-flexion-axial compression test (0.75–0.89) (39). There is no strong evidence to support the ability of these tests to distinguish between the various causes of intra-articular hip pathology, but one or more positive tests likely warrant further investigation.

**Investigations**

**Laboratory tests**

Superficial and deep infections following hip arthroscopy are quite rare, with superficial wound infections reported in less than 3% of patients (42-45), and only two reported cases of deep infection identified following hip arthroscopy (46,47). Despite their rarity, clinical suspicion should be maintained at a high level as the consequences of septic arthritis in a young patient can be devastating. Thus, if clinically indicated, a complete blood cell count, C-reactive protein, erythrocyte sedimentation rate, and image-guided joint aspiration can help to guide diagnosis (48). If necessary, hip arthroscopy is a safe and effective management strategy for septic arthritis (49), though there is no specific data on its use in a revision context.

**Diagnostic imaging**

Plain radiographs can reveal bony causes for failure of the index surgery, and should include AP pelvis, lateral of the affected hip, and a Dunn lateral in 45° of flexion which can reveal residual cam deformity (most commonly at the 1:15 position) (50). Given that bony under-resection is one of the most common reasons for revision hip arthroscopy (10), careful examination of pre- and post-operative radiographs is crucial. Bony over-resection, though much more rare, can also be identified radiographically.

Fluoroscopic or ultrasound-guided intra-articular injections (e.g., local anesthetic, or less commonly corticosteroid or hyaluronic acid) have excellent diagnostic utility in distinguishing intra-articular pathology from extra-articular and non-hip related pathology (sensitivity 0.91–1.0, specificity 0.81–1.0) (51-53). In addition, intra-articular injections represent a therapeutic option that may temporize or altogether avoid the need for revision surgery, though less than half of patients with FAI benefit from pain relief following an intra-articular injection of the hip (54).

Ultrasonographic examination may be indicated if infection is suspected to assess for a joint effusion, and may or may not be accompanied by joint aspiration. Ultrasound is also useful in assessing dynamic hip pathologies, such as subspine impingement and snapping hip syndrome (24,41). Finally, ultrasound can be used to help diagnose pathologies related to the many tendons and bursae in and around the hip joint (55).

Advanced imaging should be strongly considered in the revision arthroscopy setting. One or both of computed tomography (CT) or magnetic resonance imaging (MRI) may be necessary to identify all causes of failure and to assist in pre-operative planning. Three-dimensional reconstruction with CT or MRI can also help to more adequately and accurately target such etiologies as subtle residual bony lesions, focal acetabular over-coverage (56), and HO (50). MR Arthrography has superior diagnostic utilities compared to plain MRI for diagnosing labral tears (sensitivity 0.87, specificity 0.64) (57). Recent advances in technology have made 3D printing an important and viable option for pre-operative planning, helping to reduce operative time and increase accuracy (58). Though no literature was identified on the application of 3D printing in the context of hip arthroscopy, it is an option that may be considered in highly complex revision cases if the resources are available (e.g., dysplasia or other anatomic deformities).

**Operative management**

**Pre-operative planning**

As with any operation, careful pre-operative planning is a major determinant of post-operative outcome. Particularly in a revision setting, where the operation may be more technically challenging and the peri-operative risks greater, a detailed pre-operative plan can be the difference between success and failure. A review of history, physical examination and imaging is important in identifying the diagnosis for failure and the goals of the revision operation. A careful study of the index operative report is essential, and can help identify reasons for failure (e.g., extensive cartilage loss), procedures performed (e.g., psoas tenotomy, capsular repair vs. no repair), and technical challenges (e.g., distorted anatomy, tight musculature, etc.).

**Intra-operative strategies**

Bony under-resection, as one of the most common causes
of revision hip arthroscopy, is important to evaluate and address. Once again, the importance of pre-operative planning cannot be over-stated. Intra-operative fluoroscopy can only provide two-dimensional cuts of the joint anatomy, and residual lesions are best addressed if their location and extent have been identified with pre-operative 3D modalities (50). Thus, intra-operative fluoroscopic imaging should be used to assist the execution of the pre-operative plan, and not as a real-time diagnostic tool. Navigated cam resection is an exciting new option in which a software is used pre-operatively to simulate hip movements and identify the extent of resection required. The resection is then undertaken with active feedback from the navigation system. In one study, navigated resection lead to improved accuracy, but greater radiation exposure and longer operative time (59). Residual cam deformity most commonly occurs at the superior head-neck junction, specifically at the 1:15 position. This is likely due to the technical difficulties associated with global arthroscopic assessment in this area, which often has to be viewed through accessory portals in a regional fashion (50). Again, pre-operative planning and the use of appropriate assistive technology should be considered, particularly in a revision setting (e.g., 3D fluoroscopy, navigation software, etc.). Resection of HO lesions can be performed arthroscopy, though at least six months to one year should be allowed for full bony maturation to reduce the likelihood of recurrence (60).

The data on hip arthroscopy for chondral lesions is limited, but early data shows some promising results in the short term. A recent systematic review looking at twelve different studies on the arthroscopic management of chondral lesions found significant improvements across all cohorts (61). A number of different techniques can be used to address chondral lesions. Philippon et al. first reported on microfracture for chondral lesions in nine patients, with an average fill percentage of 91% at second-look arthroscopy (62). More recent data has corroborated this finding with positive clinical outcomes in short-term follow-up (61). Recent advances in technology have made possible exciting new techniques for the treatment of chondral lesions. Specifically, this includes whole-tissue and cell-based (with or without the use of a scaffold) transplantation techniques. In whole-tissue osteochondral transfer, autologous or allogenic osteochondral plugs are harvested from non-weight-bearing surfaces of the hip or knee joint. The recipient site in the hip joint is then drilled to the desired depth, the graft inserted, and tamped into position to achieve a congruent articular surface (63). In contrast, cell-based chondrocyte implantation requires harvesting of chondrocytes (either autologous or allogenic), and the isolation and expansion of the cells in a laboratory setting. A matrix may or may not be used to promote cell proliferation. Once the graft has matured, the recipient site is prepared for graft implantation, and the graft then implanted. Traction is released and the hip is taken through 4–6 arcs of motion, following which the graft position is confirmed. Of note, if autologous chondrocyte implantation is used, the patient must undergo two surgeries—one for harvest and another for implantation (64). Finally, the use of a synthetic osteochondral plug has been described by Field et al., in which a synthetic plug is inserted into the site of the lesion. Overall, a recent systematic review found promising results with short-term follow-up for all of the above techniques (65).

Symptomatic labral re-tear and/or insufficiency may need to be addressed in a revision setting. The options for addressing labral pathology, depending on the extent of the defect, include debridement, repair, and reconstruction. Debridement may be used for symptomatic focal tears or cysts (66). The affected labrum is debrided to a stable bleeding rim of bone, ensuring that the debridement is kept to the minimum amount required to achieve a stable flap (67). It is unclear whether simple debridement has any clinical benefit, particularly in older patients (68–71), and whether or not it results in subsequent labral regeneration (72,73). In a revision setting, if labral debridement at the index operation has failed to result in labral regrowth, repeat debridement may be of limited utility.

Labral repair is recommended for detached or torn (but not degenerative) labrum where there is sufficient high-quality tissue amenable to repair. The labrum may need to be detached carefully and held with a stay suture to allow access to the underlying acetabular rim. Some rim trimming is necessary to provide a stable, bleeding bone bed for repair (74). In a revision context, particularly if previous labral/acetabular work has been performed, care should be taken to avoid over-resection. Awareness of the pre-operative lateral centre-edge angle (LCEA) can help guide the appropriate amount of resection (75). Finally, the labrum is re-attached to the rim using one of a variety of previously described techniques, including with sutures and anchors (74,76–78).

Labral reconstruction may be indicated when a labral tear is irreparable, either due to insufficient volume or quality of tissue. In the revision setting in particular, early
evidence has shown a lower rate of failure as compared to labral repair, and may be necessary due to previously damaged and/or resected labrum (75,79). A number of different techniques have been described for arthroscopic labral reconstruction, most commonly with iliotibial or semitendinosus auto- or allografts (79). Three arthroscopic portals are required to maintain graft tension during the procedure (79). Once again, femoral and acetabular osteochondroplasty is performed as necessary to address any FAI lesions and to provide a suitable bone bed for graft fixation. The labral defect is then measured, and a graft larger than the measured size is prepared. The graft is thawed if necessary, soaked in a saline and antibiotic solution, and rolled into a ~5 mm diameter tubular graft. The graft is then introduced into the joint and tied with circumferential sutures or anchors to the bone bed. Excess graft is removed and examined dynamically and without traction for stability, to ensure there is no impingement, and to ensure restoration of the suction seal (79).

Capsular instability remains a controversial topic post-hip arthroscopy, and it is unclear if capsular repair reduces its occurrence (13). Nonetheless, both gross and micro-instability have been reported post-hip arthroscopy, and should be taken into consideration in a revision setting (12,14). In patients who have sufficient remaining capsular tissue, a direct repair, with or without plication can be performed to close and tighten the capsule following the revision operation. This procedure involves excision of a small section of capsule (an oval-shaped area 8–10×12–15 mm), the interval between which is then closed. In rare cases where there is insufficient tissue for capsular closure or repair, an allograft can be considered (60). Capsular repair and/or plication should certainly be considered in patients with known risk factors, such as female sex, global ligamentous laxity, and connective tissue disorders such as Ehlers-Danlos syndrome (13).

Capsular reconstruction may be necessary in patients with deficient capsular tissue at revision. This can be performed using the native capsular tissue in some cases by reattaching the capsule and the iliofemoral ligament to their footprint, and a capsular closure performed distal to proximal, with suture anchors at the proximal end. Sutures are used to close the capsule in a side-to-side convergence technique (80). Grafting options are available in cases of severe capsular deficiency, and a number of different techniques have been described including iliotibial band autograft (81), Achilles’ tendon allograft (82), and dermal allografts (83,84).

Bony over-resection, though rare, can also be addressed arthroscopically. Frank et al. have described a remplissage technique that can be used to correct excessive resection of a cam lesion (16). In this procedure, an iliotibial band allograft is prepared based on the shape and size of the defect. The graft is loaded onto a suture anchor and introduced into the joint. It is then positioned at the site of the defect, and tied down into the bone. Further anchors can be placed along the length of the defect. This procedure can help to restore the suction seal and address iatrogenic instability (16). As this is a recently described procedure, no clinical data is available on outcomes, including post-operative range of motion.

The above procedures can also be performed with open surgical approaches, and this may be considered in cases where arthroscopy may be deemed too difficult or unlikely to succeed, for example in the context of gross anatomic deformities or a multiply revised hip. The higher peri-operative risk and lengthier recovery with comparable open procedures versus arthroscopy should be considered when deciding on the surgical approach (85).

**Patient selection/expectation management**

Patients should be selected carefully for revision hip arthroscopy. While a majority of patients do improve following revision hip arthroscopy, 15–35% of patients are not satisfied (4,8,86). Total hip arthroplasty (8–14%) and re-revision hip arthroscopy (7–8%) are required in some patients following revision hip arthroscopy within 1–2 years (4,86). Previous literature has identified older age, cartilage injuries, workers’ compensation, and female sex as predictors of relatively poorer outcome after primary hip arthroscopy, and the same can be expected to apply to revision hip arthroscopy (87,88).

Finally, management of patient expectations is important, particularly in a revision context. A matched-cohort study comparing 246 patients requiring revision hip arthroscopy to 492 primary surgeries showed the Hip Outcome Score-Activities of Daily Living (HOS-ADL) was lower in the revision cohort preoperatively (65 vs. 70) and postoperatively (79 vs. 87) (P=0.001). A similar finding was seen with regards to the HOS-sports, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Short-Form 12 (SF12) physical component scores (89). Thus, while revision hip surgery may provide meaningful benefits to patients, it clearly emphasizes the importance of managing expectations to help improve patient satisfaction.
in the post-operative period. Hip and knee arthroplasty literature has demonstrated that pre-operative patient expectations impact post-operative patient-reported outcomes (90). Counselling patients based on the available evidence is a key component of obtaining informed consent. As well, a frank discussion regarding the possible reasons for failure of the primary surgery can help to guide diagnosis and decision-making in the revision context.

**Conclusions**

With the significant increase in the utilization of hip arthroscopy, revision hip arthroscopy is also becoming more common. Up to 6% of patients undergoing primary hip arthroscopy require revision arthroscopy. Some of the most common causes for revision surgery include inadequately addressed FAI, labral degeneration or re-tear, and degenerative joint disease. A careful history and physical is important in differentiating between intra-articular, extra-articular, and non-hip related sources of persistent or recurrent pain following hip arthroscopy. Basic and advanced imaging, including the use of three-dimensional modalities, is important in guiding diagnosis and pre-operative planning. Intra-operatively, bony lesions should be carefully and sufficiently addressed, particularly those in locations that are difficult to visualize. Labral lesions often require repair or reconstruction due to a lack of high-quality tissue. Overall, revision hip arthroscopy is less successful than index surgery and patients should be carefully selected and their expectations managed clearly.

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**Footnote**

*Conflicts of Interest:* Olufemi R. Ayeni is an educational consultant for ConMed. The other authors have no conflicts to declare.

**References**


43. Domb BG, Linder D, Finley Z, et al. Outcomes of hip arthroscopy in patients aged 50 years or older compared with a matched-pair control of patients aged 30 years or


64. Jannelli E, Fontana A. Arthroscopic treatment of chondral defects in the hip: AMIC, MACI, microfragmented adipose tissue transplantation (MAFF) and other options. SICOT-J 2017;3:43.


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