Systematic Review

# Safety Measures in Hip Arthroscopy and Their Efficacy in Minimizing Complications: A Systematic Review of the Evidence

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**Purpose:** The purpose of this systematic review was to evaluate the literature to determine complications of hip arthroscopy, with a secondary focus on how to minimize complications and risks. **Methods:** Two independent reviewers performed a search of PubMed for articles that contained at least 1 of the following terms: complications and hip arthroscopy, hip impingement, femoral acetabular impingement and complications, or femoroacetabular impingement (FAI) and complications. The search was limited to articles published between 1999 and June 2013. An additional search was performed for articles evaluating techniques on how to minimize complications. **Results:** We identified 81 studies (5,535 patients; 6,277 hips). The mean age was 35.48 years, and the mean body mass index was 25.20 kg/m$^2$. Of the participants, 52% were male and 48% were female. The majority of studies were Level IV Evidence (63%). A total of 285 complications were reported, for an overall rate of 4.5%. There were 26 major complications (0.41%) and a 4.1% minor complication rate. The overall reoperation rate was 4.03%. A total of 94 hips underwent revision arthroscopy. Regarding open procedures, 150 patients (93%) underwent either total hip arthroplasty or a hip resurfacing procedure. The conversion rate to total hip arthroplasty or a resurfacing procedure was 2.4%. **Conclusions:** Overall, primary hip arthroscopy is a successful procedure with low rates of major (0.41%) and minor (4.1%) complications. The reoperation rate was 4.03% in our review. There is admittedly a learning curve to performing hip arthroscopy, and we present a systematic review of the complications and how to minimize these complications with careful technique and planning. **Level of Evidence:** Level IV, systematic review of Level II to V studies.

The concept of femoroacetabular impingement (FAI) was first described by Ganz and colleagues[1] in 1999. Our understanding of this pathology was further enhanced by the development of open surgical hip dislocation techniques described shortly after in 2001.[2] Operative management has included surgical hip dislocation in conjunction with femoral head osteoplasty, acetabuloplasty, and addressing any chondral and labral pathology. Alternatively, arthroscopic procedures to treat FAI have also gained popularity.[3-8] Because increasing interest has been directed to the diagnosis and treatment of hip pathology, the development of hip arthroscopy has gained recognition for treating both intra- and extra-articular causes. Although the number of hip arthroscopy procedures performed in the United States is increasing rapidly,[9] this procedure is not without risks and complications. Complications described in the literature include iatrogenic chondrolabral injury, heterotopic ossification, traction neurapraxia, nerve injury related to portal placement, iatrogenic instability resulting in subluxation/dislocation, extravasation of fluid into the intra-abdominal and intrathoracic compartments, femoral neck fracture, thromboembolic disease, and death.[10-22] Clarke et al.[18] published 1 of the first prospective series of patients in which complication rates in hip arthroscopy were evaluated. They included 1,054 patients in their study and found an overall complication rate of 1.4%. They reported 1 major complication: septic

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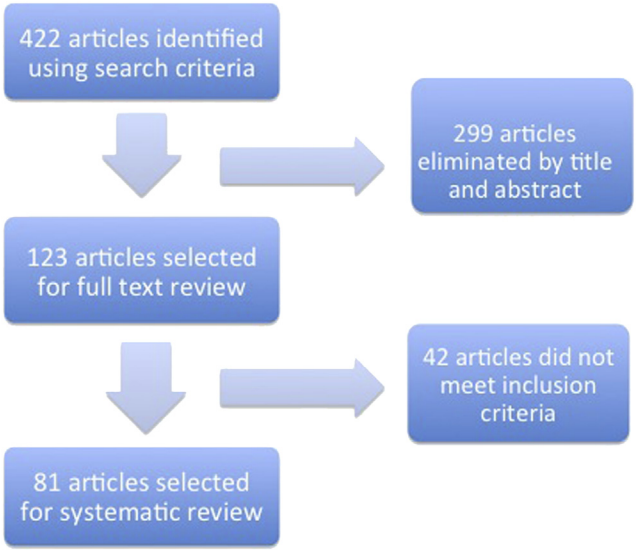


**Fig 1.** Algorithm for selecting articles from PubMed.

arthritis. In the most comprehensive study of complications to date, Harris et al.[23] conducted a systematic review looking at complications and reoperations during and after hip arthroscopy. They reviewed 92 studies (>6,000 patients) and found the rates of major and minor complications to be 0.58% and 7.5%, respectively. To date, no study has evaluated the efficacy of various safety measures in hip arthroscopy that may help reduce complication rates.

The purpose of this systematic review was to evaluate the literature on complications of hip arthroscopy, with a secondary focus on evaluating the literature for techniques on how to minimize these complications and risks.

## Methods

Two independent reviewers performed a search of PubMed for articles that contained at least 1 of the following terms: complications and hip arthroscopy, hip impingement, femoral acetabular impingement and complications, or femoroacetabular impingement (FAI) and complications. The search was limited to articles that were published between 1999 and June 2013. These dates were chosen in accordance with the first description of FAI in the literature.[1] In addition, reference lists from the relevant articles were retrieved to identify any additional studies of interest. We focused on studies that reported complications of hip arthroscopy. Secondarily, we also performed a search for studies evaluating safety measures that may minimize these complications. By use of this search method, 81 articles were found. All studies were reviewed by both reviewers. Full-text publications were obtained for relevant studies that had the potential to meet our inclusion criteria: (1) documented complications after hip arthroscopy, (2) Level of Evidence II through V, and (3) written in English. Articles were excluded if they did not include any documentation of complications after hip arthroscopy or were basic science studies, review articles, technique papers, and studies including non-arthroscopic procedures.

## Results

We identified 81 studies (5,535 patients; 6,277 hips) (Fig 1). Table 1 presents the demographic information. The mean age was 35.48 years, and the mean body mass index was 25.20 kg/m$^2$. Of the participants, 52% were male and 48% were female. The majority of studies were Level IV evidence (63%). Regarding positioning, 52% of patients were placed in the supine position and 48% in the lateral position. Preoperative diagnoses are shown in Table 2. The most common preoperative diagnosis was FAI, in 2,300 hips (37%). The next most common was labral pathology, in 1,520 patients (25%).

### Complications

A total of 285 complications were reported, for an overall complication rate of 4.5% (Table 3). There were a total of 26 major complications (0.41%) and a minor complication rate of 4.1%. The most common minor complication was the occurrence of postoperative neurapraxia (104 hips), followed by the formation of heterotopic ossification (49 hips). Iatrogenic cartilage scuffing or labral penetration developed in 24 hips (0.38%) in our review. The most common major complication was abdominal fluid extravasation (13 hips), followed by instrument breakage (11 hips).

### Reoperations

The overall reoperation rate was 4.03%, as presented in Table 4. A total of 94 hips underwent revision arthroscopy, with a large proportion (81%) of those hips

**Table 1.** Demographic Data

| | Data |
|---|---|
| No. of studies analyzed | 81 |
| Level of Evidence [n (%)] | |
| II | 3 (4) |
| III | 8 (10) |
| IV | 53 (63) |
| V | 17 (21) |
| Participants [n (%)] | |
| Male | 2,883 (52) |
| Female | 2,652 (48) |
| No. of hips | 6,277 |
| Mean age (yr) | 35.48 |
| Mean body mass index (kg/m$^2$) | 25.20 |
| Mean follow-up (mo) | 22.90 |
| Mean operative time (min) | 94.96 |
| Mean traction time (min) | 45.78 |
| Position [n (%)] | |
| Supine | 3,316 (52) |
| Lateral | 3,039 (48) |

**Table 2.** Preoperative Diagnosis (n = 6,160)

| | n | % |
|---|---|---|
| FAI | 2,300 | 37 |
| Labral pathology | 1,520 | 25 |
| Other | 505 | 8 |
| Degenerative joint disease (Tönnis grade >0) | 723 | 12 |
| Chondral defect/damage | 268 | 4 |
| Peritrochanteric disorders | 205 | 3 |
| Loose or foreign bodies | 237 | 4 |
| Dysplasia | 70 | 1 |
| Iliopsoas tendon pathologic process | 40 | 1 |
| Athletic/sports pubalgia | 37 | 1 |
| Osteonecrosis | 37 | 1 |
| Legg-Calvé-Perthes disease | 35 | 1 |
| Synovial disorder | 33 | 1 |
| Free-vascularized fibular grafting | 32 | 1 |
| Osteochondromatosis | 27 | 0 |
| Post-traumatic cause | 22 | 0 |
| Acetabular pathoanatomy | 21 | 0 |
| Inflammatory arthritis | 21 | 0 |
| AVN | 14 | 0 |
| PVNS | 6 | 0 |
| Ligamentum teres pathologic process | 3 | 0 |
| Capsular adhesions | 1 | 0 |
| Coxa valga | 1 | 0 |
| Exostosis of greater trochanter | 1 | 0 |
| Sacroiliac arthrodesis | 1 | 0 |

PVNS, pigmented villonodular synovitis.

not having the second procedure defined. We presume that a significant number of these hips presented with a preoperative diagnosis of residual FAI with under-resection of either the cam or pincer lesion. Excision of heterotopic ossification (5%) was the next most common procedure. Regarding open procedures, 150 patients (93%) underwent either total hip arthroplasty or a hip resurfacing procedure. The conversion rate to total hip arthroplasty or a resurfacing procedure was 2.4%.

## Discussion

### Review of Literature on Techniques to Minimize Complications and Risks

We subsequently performed a literature review on complications and how to minimize them during hip arthroscopy. Table 5 presents a summary of these pearls and pitfalls in addition to the senior author's recommendations.

*Labral Penetration/Cartilage Scuffing.* Iatrogenic labral penetration most commonly occurs during establishment of the initial portal. Badylak and Keene[19] evaluated 250 consecutive patients who underwent hip arthroscopy and found 50 iatrogenic labral penetrations (20%). Domb et al.[20] recently published an article on 300 consecutive patients undergoing hip arthroscopy and found iatrogenic labral penetration in only 2 patients (0.67%). They proposed careful management of the 14-gauge spinal needle during initial joint access. After, the needle is inserted

**Table 3.** Postoperative Complications (n = 285)

| | n | % |
|---|---|---|
| HO | 49 | 17 |
| Nerve injury | | |
| Numbness | 12 | 4 |
| Other | 39 | 14 |
| Pudendal | 30 | 11 |
| Sciatic | 23 | 8 |
| Iatrogenic | 22 | 8 |
| Scuffing | 20 | 7 |
| Abdominal fluid extravasation | 13 | 5 |
| Instrument breakage | 11 | 4 |
| Perineal skin damage | 10 | 4 |
| Hematoma | | |
| Excessive bleeding from portals | 3 | 1 |
| Labial hematoma | 3 | 1 |
| Portal hematoma | 3 | 1 |
| Scrotal hematoma | 1 | 0 |
| Thigh hematoma | 5 | 2 |
| Labral damage | 4 | 1 |
| Infection | 4 | 1 |
| Deep vein thrombosis | 4 | 1 |
| Muscle pain | 4 | 1 |
| Femoral neck fracture | 3 | 1 |
| Hip dislocation | 3 | 1 |
| Pulmonary embolus | 2 | 1 |
| Trochanteric bursitis | 2 | 1 |
| Hypothermia | 2 | 1 |
| Septic joint | 2 | 1 |
| Abdominal compartment syndrome | 2 | 1 |
| Technical failure (conversion to open) | 1 | 0 |
| CRPS | 1 | 0 |
| Capsular adhesion | 1 | 0 |
| Hip instability | 1 | 0 |
| Ankle pain | 1 | 0 |
| Hypothermia | 1 | 0 |
| Vascular obstruction of ankle | 1 | 0 |
| Osteonecrosis of femoral head | 1 | 0 |
| Other | 1 | 0 |

CRPS, complex regional pain syndrome; HO, heterotopic ossification.

**Table 4.** Reoperations

| | n | % |
|---|---|---|
| Arthroscopic (n = 94) | | |
| Arthroscopic—undefined | 76 | 81 |
| Excision of HO | 5 | 5 |
| Loose body removal | 3 | 3 |
| Capsular plication | 2 | 2 |
| Chondroplasty | 2 | 2 |
| Osteochondroplasty | 2 | 2 |
| Ligamentum teres debridement | 1 | 1 |
| Microfracture | 1 | 1 |
| Revision labral repair | 1 | 1 |
| Synovectomy | 1 | 1 |
| Open (n = 159) | | |
| THA | 131 | 82 |
| Resurfacing | 11 | 7 |
| THA or resurfacing (no differentiation) | 7 | 4 |
| Excision of HO | 5 | 3 |
| Arthrotomy | 2 | 1 |
| Capsular repair | 1 | 1 |
| Core decompression | 1 | 1 |
| Open treatment of cam | 1 | 1 |

HO, heterotopic ossification; THA, total hip arthroplasty.

**Table 5.** Pearls and Pitfalls During Hip Arthroscopy

| Pitfalls | Pearls |
|---|---|
| Femoral head scuffing | Place bevel of spinal needle toward femoral head during venting. |
| | Avoid over-penetration of trocar during insertion. |
| Anchor penetration of cartilage | Consider curved drill guides. |
| | Perform careful placement of anchors near 3-o'clock position. |
| | Monitor articular cartilage while drilling. |
| Over-resection | Use intraoperative fluoroscopy to continuously measure resection depth, with care not to remove >30% during femoral neck osteoplasty. |
| Neurapraxia | Use the lowest amount of traction force necessary for adequate distraction. |
| | Consider placing patient in Trendelenburg position to take pressure off perineum. |
| | Use a well-padded perineal post. |
| | Avoid entrapment of scrotum and labia during traction. |
| Abdominal compartment syndrome | Avoid hip arthroscopy acutely after acetabular fracture. |
| | Perform iliopsoas fractional lengthening toward end of procedure. |
| | Perform frequent abdominal compartment palpation. |
| | Monitor intraoperative hypotension. |
| | Avoid high pump pressure. |
| Iatrogenic hip dislocation | Avoid excessive acetabular resection in dysplastic hips. |
| | Consider capsular plication in patients with ligamentous laxity. |
| | Attempt preservation of zona orbicularis. |
| Femoral neck fracture | Counsel patients on restricted weight bearing after femoral neck osteoplasty. |
| | Avoid >30% resection during femoral neck osteoplasty with cortical notching. |
| AVN of femoral head | Take care to avoid excessive traction and intra-articular pressure. |
| | Carefully avoid lateral epiphyseal vessels. |

through the anterolateral portal toward the inferior part of the joint space with the bevel facing toward the femoral head to minimize femoral head scuffing. Once the joint has been vented and maximal distraction achieved, the needle is reinserted with the bevel facing the labrum to minimize the risk of labral penetration. The needle is then inserted further into the joint with the bevel facing the femoral head to avoid any damage to the articular cartilage. Aoki et al.[24] proposed fluoroscopic positioning of the spinal needle anterior to the level of the superior femoral head instead of the clear space to decrease the potential for labral penetration. Similarly, the bevel of the needle is oriented toward the femoral head to avoid articular cartilage damage. In addition, they stated that tactile feedback should be used to determine trocar penetration of the capsule and avoiding over-advancement of the trocar, which can lead to cartilage scuffing of the femoral head. McCarthy and Lee[25] reported a 3% rate of mild chondral scuffing that was associated with difficult distraction including protrusion deformity and degenerative joint disease.

The senior author's recommendations for avoiding labral penetration/cartilage scuffing are as follows:

- Place the bevel of the spinal needle toward the femoral head during venting.
- Avoid over-penetration of the trocar during insertion.
- Ensure adequate distraction of the joint before insertion of the trocar and camera.

*Anchor Penetration of Cartilage.* Hernandez and McGrath[26] evaluated 9 fresh-frozen human cadaveric hips to ascertain a "safe angle" for suture anchor insertion to facilitate anchor placement within bone and prevent intra-articular penetration. They developed guidelines for danger angles and safe angles of anchor insertion to improve fixation in bone and lessen intra-articular penetration. They found that along all locations of the bony acetabular rim, the size of the anchor was inversely proportional to the size of the safe angle. They also quantified the distance from the tip of the bony acetabulum to the labral insertion to avoid intra-articular damage with labral repair. Lertwanich et al.[27] created 3-dimensional acetabular models based on computed tomography scans of 20 cadaveric hip specimens. They reported that clock position, drill depth, and rim trimming all had significant effects on the acetabular rim angle ($P < .0001$). The acetabular rim angle was largest at the 2-o'clock position and smallest at the 3-o'clock position. They concluded that greater drill depths provided smaller rim angles whereas rim trimming provided larger acetabular rim angles. Extra care must be taken when drilling or inserting anchors around the 3-o'clock position. Nho et al.[28] used computed tomographic analysis to evaluate the placement of suture anchors for labral fixation with straight and curved guides. They found that the curved suture anchor guide significantly increased the insertion angle ($P = .009$) and distance from the articular cartilage to the anchor ($P = .003$) at the 1-o'clock position. The angle of insertion at the 2- and 3-o'clock positions was greater for the curved suture anchor guide; however, this did not reach statistical significance.

The senior author's recommendations for avoiding anchor penetration of the cartilage are as follows:

- Consider using curved drill guides.
- Perform careful placement of anchors near the 3-o'clock position.
- Monitor the articular cartilage while drilling.

*Under-Correction and Over-Resection.* Under-correction of FAI has been shown to be a common cause of revision hip arthroscopy. Philippon et al.[29] performed a retrospective review of 37 revision hip arthroscopy patients. They

found that 34 patients (95%) had residual FAI and 35 patients (97.2%) had radiographic signs of FAI. Heyworth et al.[30] retrospectively reviewed 24 patients who underwent revision hip arthroscopy and found that 19 patients (79%) had unaddressed or undertreated bony impingement lesions. Over-resection of the femoral cam can result in cortical notching or femoral neck fracture.[13] Wijdicks et al.[31] performed an in vitro biomechanical evaluation of iatrogenic femoral cortical notching and risk of femoral neck fracture. They concluded that 4.0-mm and 6.0-mm cortical notching depths resulted in significant load to failure and energy compared with the intact state. Similarly, Mardones et al.[32] performed a cadaveric study and concluded that resection of up to 30% of the anterolateral quadrant of the head-neck junction did not significantly alter the load-bearing capacity of the proximal part of the femur. Greater than 30% resection significantly decreased the amount of energy required to produce a fracture.

The senior author's recommendations for avoiding under-correction and over-resection are as follows:

- Use intraoperative fluoroscopy to continuously measure the resection depth; obtain multiple fluoroscopic angles to confirm the completion of resection.
- Avoid removal of greater than 30% during femoral neck osteoplasty.

*Neurapraxia.* Telleria et al.[33] performed intraoperative sciatic nerve monitoring in 60 patients undergoing traction during hip arthroscopy. They found that 35 patients (58%) had intraoperative nerve dysfunction and 4 (7%) sustained a clinical nerve injury. They found that the average traction weight, and not the total traction time, is the greatest risk factor for sciatic nerve dysfunction during hip arthroscopy. The odds of a nerve event increased by 4% with every 0.45-kg (1-lb) increase in the traction amount. More recently, Dippmann et al.[34] prospectively reviewed 52 consecutive patients who underwent hip arthroscopy to analyze the rate, pattern, and severity of symptoms of nerve dysfunction postoperatively and to evaluate whether symptoms are related to traction time. They found that 46% of patients reported symptoms of nerve dysfunction within the first 6 weeks after surgery. One year postoperatively, only 18% of patients continued to have symptoms. Similarly, traction time during surgery was not different in patients with and without symptoms of nerve dysfunction. Mei-Dan et al.[35] evaluated 170 patients placed supine in 15° to 20° of Trendelenburg without the use of a perineal post with traction applied. Hip distraction was achieved as a result of the friction between the patient's body and the operating table. No neurapraxia was found in any patient immediately postoperatively, at 1 and 14 days postoperatively, and at 3 and 6 months postoperatively.

The senior author's recommendations for avoiding neurapraxia are as follows:

- Use the lowest amount of traction force necessary for adequate distraction.
- Consider placing the patient in the Trendelenburg position to take pressure off the perineum.
- Use a well-padded perineal post.
- Avoid entrapment of the scrotum and labia during traction.

## Rare/Catastrophic Complications

### Abdominal Compartment Syndrome

Several case reports have described fluid extravasation into the abdominal compartment during hip arthroscopy.[12,36-39] Report of death and cardiac arrest due to abdominal compartment syndrome have both been documented. Bartlett et al.[39] presented a case of hip arthroscopy after acetabular fracture for removal of intra-articular fragments. During the procedure, arthroscopic fluid extravasated through the fracture site, resulting in an intra-abdominal compartment syndrome that presented as cardiopulmonary arrest. In this case report, the authors advised avoiding hip arthroscopy in the acute period after acetabular fracture to avoid extravasation. Hypotension appears to be a cardinal sign for increased abdominal pressure, and both careful monitoring by the anesthesiologist and regular abdominal checks by the orthopaedic surgeon should occur throughout the procedure. Kocher et al.[40] conducted a survey of 15 hip arthroscopists and found an approximate prevalence of intra-abdominal fluid extravasation of 0.16%. The mean operative time was 120.2 minutes, with 63% of patients undergoing iliopsoas tenotomy. Among the patients who underwent iliopsoas tenotomy, the complication occurred in 44% at the beginning of the procedure and 4% in the middle of the procedure. Significant risk factors were higher arthroscopic fluid pump pressure and concomitant iliopsoas tenotomy. The authors proposed careful monitoring of the patient's blood pressure and core temperature throughout the procedure. Stafford et al.[41] recently reported mean extravasation of 1,132 mL of irrigation fluid into periarticular tissues. They found a significant correlation between the volume of extravasated fluid and both the length of the operation and the volume of infused fluid used.

The senior author's recommendations for avoiding abdominal compartment syndrome are as follows:

- Avoid hip arthroscopy acutely after acetabular fracture.
- Perform iliopsoas fractional lengthening toward the end of the procedure.
- Perform frequent abdominal compartment palpation.
- Monitor intraoperative hypotension.
- Avoid high pump pressure.

### Iatrogenic Hip Dislocation

Matsuda[11] presented a case report of an iatrogenic anterior hip dislocation after arthroscopic surgery that involved supranormal hip distraction for extraction of an iatrogenic loose body. Closed dislocation failed to provide adequate reduction, and the patient eventually underwent mini-open capsulorrhaphy, which successfully restored stability. Possible causes for dislocation include iatrogenically caused dysplastic hip with over-resection of the acetabular rim and attenuation of the capsule with prolonged traction. Over-resection of the acetabular rim can theoretically convert a normal or over-covered acetabulum to a dysplastic acetabulum with a lateral center-edge angle of less than 20°. Ito et al.[42] performed a cadaveric study on the biomechanical importance of the proximal capsule and the zona orbicularis to stability. They found that the zona orbicularis functioned as a "locking ring" around the femoral neck, providing resistance to dislocation.

The senior author's recommendations for avoiding iatrogenic hip dislocation are as follows:

- Avoid excessive acetabular resection in dysplastic hips.
- Consider capsular plication in patients with ligamentous laxity.
- Attempt to preserve the zona orbicularis; if incised, then perform a repair at the conclusion of the procedure.

*Femoral Neck Fracture.* Ayeni et al.[13] presented the first case report of a nondisplaced subcapital femoral neck fracture 5 weeks postoperatively from hip arthroscopy with femoral neck osteoplasty. Postoperative radiographs confirmed appropriate resection; however, the patient did report aggressive weight-bearing activities against recommendations. The fracture was treated with open reduction—internal fixation.

The senior author's recommendations for avoiding femoral neck fracture are as follows:

- Counsel patients on restricted weight bearing after femoral neck osteoplasty.
- Avoid greater than 30% resection during femoral neck osteoplasty with cortical notching or irregularities of the burred region.

*Avascular Necrosis of Femoral Head.* Avascular necrosis (AVN) of the femoral head has been reported in several case reports in the literature. In both reports reviewed in this study, the presumed cause of iatrogenic AVN was increased traction time and/or increased intra-articular pressure.[43,44] Factors linked to AVN after hip arthroscopy include distraction, partial capsulectomy, and insult to the lateral epiphyseal branch of the medial femoral circumflex artery.[10] The lateral synovial fold is a reliable landmark used in hip arthroscopy to identify the branches of the medial femoral circumflex artery. The lateral extent of femoral osteochondroplasty should terminate just before this fold.[17]

The senior author's recommendations for avoiding AVN of the femoral head are as follows:

- Take care to avoid excessive traction and intra-articular pressure.
- Carefully avoid the lateral epiphyseal vessels during femoral neck osteoplasty.

### Limitations

Limitations of this systematic review include selection bias based on our search criteria. Most studies are retrospective in nature. Most of the studies reported are from high volume hip arthroscopy surgeons, therefore, the possibility of an underestimation of complications rates compared to general orthopedic surgeons may occur. While we presented the senior author's recommendations, this is an inherent form of bias for the reader. Additionally, surgeons may classify preoperative diagnoses and operative procedures differently, which may introduce systematic errors when aggregating data.

## Conclusions

Overall, primary hip arthroscopy is a successful procedure with low rates of major (0.41%) and minor (4.1%) complications. The reoperation rate was 4.03% in our review. There is admittedly a learning curve to performing hip arthroscopy, and we present a systematic review of the complications and how to minimize these complications with careful technique and planning.

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