Musculoskelet Surg (2017) 101:119–131
DOI 10.1007/s12306-016-0444-x

ORIGINAL ARTICLE

Hip arthroscopy complications regarding surgery and early postoperative care: retrospective study and review of literature

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Received: 18 July 2016 / Accepted: 27 November 2016 / Published online: 7 December 2016

Abstract
Purpose The purpose is to describe the rate of complications in a series of hip arthroscopies performed at our center, as well as perform a systematic review of the current literature in order to compare our outcomes.
Methods Two hundred and fifty-eight patients affected of femoroacetabular impingement and treated with hip arthroscopy have been studied. All minor and major complications were studied during the first postsurgery year. Furthermore, a systematic review was performed comparing major and minor complications with our series. Two attending orthopedic surgeons selected the different studies with the same inclusion and exclusion criteria, remaining with 48 studies that have been reviewed and included in the present study.
Results Mean age was 36.6 years old (SD 17.45), and the ratio men:women was 137:121. The mean complication rate observed was 14.34% (37/258) of global complications. Only three patients showed major complications: femoral neck fracture, septic arthritis and avascular necrosis of the femoral head. Any of these patients had permanent side effects.
Conclusions Hip arthroscopy has a low rate of major complications, but a higher number of minor complications that could be avoided with certain preventive measures.

Keywords Hip arthroscopy · Complications · Early postoperative complications · Systematic review · Femoroacetabular impingement

Introduction

The first hip arthroscopy described dates of 1931, although this technique was not very supported by its author [1]. However, during the past few decade, hip arthroscopy has been winning popularity throughout the world thanks to a technical and scientific development [2, 3]. From 1999 to 2009, the number of hip arthroscopies multiplied by 18 [4, 5]. The increase in indications has aid to its development, being currently considered as a therapeutic treatment following conservative treatments and as a preventive measurement of development or progress of intra-articular injuries such as femoroacetabular impingement (FAI) [6–8].

Ganz in 1999 first described the concept of FAI, as well as its treatment through open techniques [9, 10]. At the same time, treatment of FAI through arthroscopy was also described, significantly contributing to the development and progress of this specific technique [11–16].

The number of hip arthroscopies is increasing around the world and thus increasing too the number and type of complications related to this technique [17]. The complication rate varies from of 1.34 to 15% according to previous studies [18–23]. Complications range from iatrogenic

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injuries such as chondrolabral injuries, nerve injuries associated with portals, instability secondary to surgery that involves dislocation or subluxation, or much severe injuries such as the extravasation of fluid to the peritoneal cavity, fracture of femoral neck, thromboembolic disease and even death [21, 24–37].

The present study describes our complication rate within hip arthroscopy. Moreover, a review of the existing literature was performed in order to compare and evaluate our results. Our hypothesis is that besides the minor or major complications that can occur, hip arthroscopy continues to be a safe surgical technique.

Methods

A retrospective study was carried out with patients who had undergone hip arthroscopy between January 2011 and January 2014. Inclusion criteria were patients over 18 years old, undergoing hip arthroscopy due to labrum, FAI and low or moderate chondral lesions causing FAI (Table 1). Exclusion criteria were patients with previous surgeries on the same hip or other hip arthroscopy indications (synovial diseases, early osteoarthritis, teres ligament tears).

Surgery was performed in all patients by the same anesthetic and surgical team, with an over 5-year experience in this field and over 70 hip arthroscopies performed per year. A combined intra- and epidural anesthesia was used in all cases, using bupivacaine and a catheter that was removed at the end of surgery.

The hip was prepared and draped in the usual sterile fashion, and traction was applied with a hip distractor and a well-padded counterpost (Hip Positioning System, Smith and Nephew, Memphis, USA). C-arm fluoroscopy was used to confirm adequate distraction. Diagnostic arthroscopy was then performed using a mid-anterior (first access) and an anterolateral portal created under spinal needle localization. Intra-articular structures including the chondral surfaces of the femoral head and acetabulum, ligamentum teres, labrum, capsule, as well as the acetabular rim and femoral neck were examined. Pathologic processes at these sites were addressed surgically as needed.

Table 1 Diagnosis of patients included in the present study

Main diagnosis	Number of patients	% of total
FAI + labral injury	154	59.7
FAI	53	20.5
Chondral lesion associated with FAI	51	19.8
Total	258	100

FAI femoroacetabular impingement

After surgery, all patients received enoxaparin 40 mg daily for 10 days as preventive method of deep vein thrombosis (DVT). Diclofenac 75 mg every 12 h was prescribed during the first 2 weeks postoperative as NSAID. Metamizole 2 g every 8 h was used in case of severe pain, associated with NSAIDs.

Diagnosis, surgical and follow-up data of all patients with hip arthroscopy performed at our center were collected taking into account the early complications following surgery, considering early complications as those occurring during the first 6 months after surgery. As routine tests during postoperative care, a blood test was performed the day after surgery and an X-ray at the 2-weeks follow-up visit. Patients remained inpatients approximately 24 h and seen at the outpatient clinic 2 weeks after surgery to remove wound sutures. If any complication occurred meanwhile or after, the patients could attend the emergency room of our clinic 24/7. Minimum follow-up for inclusion in the present study was 1 year.

Sample size

The primary outcome for the present study was the incidence of complications in patients who were undergoing hip arthroscopy. Therefore, a mean complication rate was performed from previous studies obtaining 4.16% of complications (Table 2).

We hypothesized that a 95% confidence interval (CI) of ±3% around the complication rate would have high precision. Using normal approximation to binomial distribution, we calculated that a sample size of 170 patients would be required to produce a 95% CI ±3%, with an α level of 0.05. Thus, we planned to recruit all eligible patients to

Table 2 Complication rates following hip arthroscopy of the previous studies currently available

Authors	Number of arthroscopies	Complication rate (%)
Gupta et al.	6277	4.5
Harris et al.	6134	0.5–7.5
Kowalczuk et al.	6962	4
McCarthy et al.	1500	5
Chan et al.	236	4.2
Mockel et al.	13,154	6.3
Clarke et al.	1054	1.4
Sampson et al.	530	6.4
Griffin et al.	640	1.6
Mean	4054.11	4.16

Only systematic reviews were selected

Table 3 Different complications and number of affected patients for each specific complication, as well as the number of secondary effects observed within our series

Type of complication	Number of observed cases	Number of reoperated cases	Number of cases with sequelae
Iliotibial band syndrome	9	3	0
Lateral cutaneous femoral nerve injury	6	0	2
Instrumental breakage	5	0	0
Heterotopic ossification	4	0	0
Pudendal lesion	3	0	0
Capsular adhesion	3	3	0
Skin burns	2	0	0
Painful scar	2	2	0
Infection	1	1	0
Stress fracture	1	0	0
Avascular necrosis	1	0	0
Total	37	9	2

increase precision. Our sample size of 258 exceeded the CI ±3%.

Results

Two hundred and fifty-eight patients underwent hip arthroscopy between January 2011 and January 2014 at our center, diagnosed of FAI (Cam, Pincer or combined), labral lesion or FAI due to degenerative disease with Tönnis 1 or 2 (Table 1).

Mean age was 36.6 years old (SD 17.45, range 18–61). In total, 137 men and 121 women were included. Global complication rates are described in Table 3.

Forty-eight articles were included in the review performed for the present study following the inclusion criteria above mentioned, which have been classified according to the level of evidence and type of article (Table 4). Furthermore, different studies regarding the study subject that we considered could contribute to the present study were included.

Neural complications

Different neuropathies over the perineum were observed in three patients regarding traction over the hip distractor. Two cases were men with penis dysesthesias, complaining of erectile disorders that were resolved in both cases within 6 weeks. The remaining patient was a woman with mild swelling of the labia majora and dysesthesia of her perineum having trouble for sitting and inability to ride a bicycle for 4 weeks.

Eight cases of neuropathy appeared in relation to portals. The lateral femoral cutaneous nerve was affected in six cases. One patient presented hyperesthesia that remained as a sequel and the remaining five cases presented dysesthesias, three of which resolved in less than 8 weeks, one after a year and the last case remained at the end of follow-up. Two patients complaint of painful scars from portals, and these were resolved after resection of skin flap (Friedrich's excision) under local anesthesia.

Soft tissues complications

Burn injuries occurred in two cases regarding the use of radio frequency equipment with suction system. This event occurred due to a misuse of the equipment; leaving a free fall of the suction system led to a high-temperature serum output that associated with a blockage of water bags favored second-degree burns that have not required surgical treatment although they did need cutaneous treatment for 2 weeks (with complete resolution).

During 6 weeks (2–6 weeks) after surgery, we observed an increase of painful symptoms from the ipsilateral iliotibial band in some of the operated patients, forcing specific fascia lata stretching to minimize this complication. The data were from nine cases of which six were corrected with the fascia lata physical therapy. Three patients finally required surgical treatment after 3 months of physical therapy without improvement of pain, performing a Z-plasty of the iliotibial band in the region of the femur epicondylar. All cases were resolved without further complications. This complication has been associated with several causes, including lack of prior mobility or the more advanced stages of degeneration joint.

Surgical equipment break

The surgical equipment broke in five cases, and although all the ruptures could be removed without complications,

Table 4 Description of the studies included in the systematic review of hip arthroscopy complications described in flowchart of Fig. 2

References	Level of evidence	Type of paper	Classification Clavien–Dindo	Number of hip arthroscopies	% complications	Complications
Collins et al. [106]	4	Review + series	2	39	23	Deep vein thrombosis (DVT), worsened pain, heterotopic ossification (HO), return labrum, localized muscle necrosis, skin infection
Austin et al. [78]	4	Case report	3b	1		Hip dislocation
Beutel et al. [109]	3	Cohorts	3b	18	5.50	Re-rupture labrum
Curtin et Friebe [66]	4	Case report	1	1		Dermal burn
Gupta et al. [40]	4	Review	4	6277	4.50	Neurapraxia, heterotopic ossification, abdominal fluid extravasation, instrument breakage
Park et al. [54]	4	Review	3b	200	15	Neurapraxia, ankle pain, insufficient resection, instrument breakage, heterotopic ossification
Dietrich et al. [64]	3	Cohorts	3b	317	6.60	Neurapraxia, insufficient resection, insufficient traction, instrument breakage, hematoma, femoral neck fracture
Mockel et al. [24]	4	Review + series	3b	13,154	6.30	Neurapraxia, skin abrasion, instrument breakage, abdominal fluid extravasation, hematoma, infection, heterotopic calcification, DVT
Chan et al. [4]	4	Review + series	3b	236	4.20	Hip dislocation, DVT, septic joint neurapraxia, superficial wound infection, heterotopic ossification, capsular adhesion
Pailhe et al. [46]	4	Review + series	1	150	2*	*Only risk of pudendal neuralgia
Oak et al. [23]	4	Review	4	No data	4	Compression injuries, neurapraxia, aberrant portal placement, iatrogenic lesion, compartment syndromes, avascular necrosis, mechanical failure, femoral neck fracture, heterotopic ossification, hip instability, infection, thromboembolic disease
Greene et al. [105]	4	Review	1	1363 with LWH/926 without	1.03*/7.78*	*Only risk of vascular thromboembolism
Papavasiliou et Bardakos [38]	4	Review	4	No data	0.5–6.4	Traction related injuries, iatrogenic chondral and labral injuries, fluid extravasation, infection, DVT, instrument breakage, avascular necrosis, portal related complications, femoral neck fracture, instability, heterotopic ossification, inadequate osseous reshaping, adhesions
Harris et al. [41]	4	Review	4	6134	0.58–7.5	Nerve injury, iatrogenic chondral and labrum injury, perineal skin damage, infection, pulmonary embolus, avascular necrosis, heterotopic ossification, reflex sympathetic dystrophy, instrument breakage, femoral neck fracture, hypothermia, hip dislocation, fluid extravasation, vascular injury, death
Jaekers et al. [99]	4	Case report	4	1		Fluid extravasation
Badakos et Papavasiliuo [92]	4	Letter to editor	4	1		Fluid extravasation

Table 4 continued

References	Level of evidence	Type of paper	Classification Clavien–Dindo	Number of hip arthroscopies	% complications	Complications
Ong et al. [113]	4	Review + series	3b	66	12*	*Only risk of heterotopic calcification
Telleria et al. [48]	4	Review + series	4	60	23	Nerve injury, superficial wound infections, iatrogenic chondral lesions, instrumental breakage, atrial fibrillation
Kocher et al. [96]	4	Review	4	25,648	0.16*	*Only risk of fluid extravasation
Kowalczuk et al. [39]	3	Review	4	6962	4	Fluid extravasation, dislocations, DVT, septic arthritis, avascular necrosis, femoral neck fracture, heterotopic calcification, iatrogenic chondral lesions, neural injuries
Parodi et al. [67]	4	Review + series	1	73	2.7*	*Only risk of hypothermia
Domb et al. [34]	4	Review + series	1	300	0.67*	*Only risk of iatrogenic labral lesions
Mei-Dan et al. [74]	4	Case report	3b	1		Instability
Bedi et al. [36]	3	Cohorts	1	616	4.7*	*Only risk of heterotopic calcification
Said et al. [57]	4	Case report	3a	1		Vascular thromboembolism
Alaia et al. [103]	4	Case report	3a	1		DVT
Nwachukwu et al. [42]	4	Review + series	1	218	1.80	Transient pudendal palsy, instrument breakage, suture abscess
Gaudelli et Mohtadi [104]	4	Case report	2	1		DVT
Simpson et al. [59]	4	Review	4	No data	No data	Perineal lesions, nerve injury, iatrogenic chondral lesions, instrumental breakage, instability, fluid extravasation, infection, bleeding
Verma et Sekiya [95]	4	Case report	2	1		Fluid extravasation
Souza et al. [45]	4	Review + series	3b	194	6.10	Neurological complications, musculoskeletal lesions, vascular/ischemic lesions
Scher et al. [68]	4	Case report	3b	1		Avascular necrosis
Ladner et al. [91]	4	Case report	1	1		Fluid extravasation
Fowler et Owens [26]	4	Case report	3b	1		Fluid extravasation
Sharma et al. [93]	4	Case report	3b	1		Fluid extravasation
Matsuda [25]	4	Case report	3b	1		Instability
Bushnell et Dahners [29]	4	Case report	5	1		VTE, pulmonary embolism, death
Ilizaliturri [31]	4	Review	4	No data	1.50	Neurapraxia, fluid extravasation, iatrogenic chondral lesions, DVT, incomplete reshaping, avascular necrosis, femoral neck fractures, instability,
Haupt et al. [97]	4	Case report	1	1		Fluid extravasation
Smart et al. [114]	4	Review	1	No data	0.5–6.4	Neural lesions, neurovascular lesions, fluid extravasation, iatrogenic chondral lesion

Table 4 continued

References	Level of evidence	Type of paper	Classification Clavien–Dindo	Number of hip arthroscopies	% complications	Complications
McCarthy et Lee [22]	4	Review	1	1500	5	Neurapraxias, chondral scuffing
Lo et al. [37]	4	Review + series	1	73	7	Neurapraxia, chondral lesions
Clarke et al. [32]	4	Review + series	3b	1054	1.40	Septic arthritis, neurapraxia, vaginal tear, trochanteric bursitis, portal bleeding, portal hematoma, instrument breakage, arthrotomy, failure of adequate access or observation
Sampson [21]	4	Review + series	1	530	6.40	Neurapraxia, fluid extravasation, instrument breakage, scuffing, avascular necrosis
Griffin et Villar [20]	4	Review + series	1	640	1.6	Neurapraxia, fluid extravasation
Bartlett et al. [94]	4	Case report	4	1		Fluid extravasation
Funke et Munzinger [18]	4	Review + series	1	19	15.78	Neurapraxia, hematoma, fluid extravasation
DiStefano et al. [58]	4	Case report	1	3	No data	Neurapraxia

the removal increased the surgical time in a few minutes, which we did not consider long enough to alter the surgical results. The wire of nitinol broke in two cases, another patient had the bit of an anchor broken and the other two cases part of the head of radio frequency.

Systemic complications

In a group of 35 patients included in the present study, we performed blood analysis 24 h after surgery to verify the anemic status, due to the risk of bleeding in this type of surgery. A loss of over 6 points of hematocrit and 2 mg of Hb, statistically significant, were observed; whereas no statistically significant change was detected within white blood cells, platelets and biochemical pattern.

Bone complications

The most severe complications occurred during the first postoperative weeks. One patient complaint of increased pain during deambulation after 5 weeks and a non-displaced stress fracture of the femoral neck was observed. The patient was a 59-year-old male who had undergone a resection of CAM-type injury in an osteopenic bone and started full weight bearing too fast (full weight bearing only 2 weeks after surgery). Although the fracture was non-displaced, no weight bearing during 6 weeks was required until consolidation of the fracture. The patient did not require osteosynthesis.

One patient described a sudden pain that forced to non-weight bearing observing an image of avascular necrosis of the femoral head by magnetic resonance imaging (MRI), which was treated with 30 min of magnetic fields for 3 months, resolving the painful symptoms and improving the MRI image, being able to return to his fully sports activities 6 months later (Tegner 9) (Figs. 1, 2).

Complications requiring revision arthroscopy

One patient presented, during the fifth postoperative week and following an episode of tonsillitis with fever, sudden pain of the hip with analytical parameters of infection. A debridement arthroscopy was performed, and although the cultures resulted negative, the episode was treated as a hematogenous infection possibly due to oropharynx bacteria. After 6 weeks of antibiotic therapy, the patient progressed favorably, returning to his sports activity level (Tegner 9) 4 months after the initial surgery.

Difficulties for moving the joint were observed in three patients, requiring at 3, 4 and 6 months a cleaning arthroscopy together with wide capsulotomy in order to recover the joint's mobility, obtaining a favorable outcome in all patients after this second surgery, which consisted of arthrolysis with release of the capsular recess and labrum.

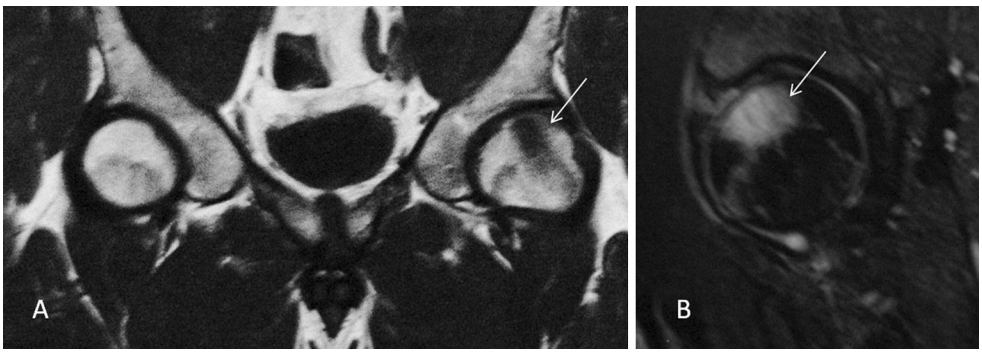

Fig. 1 Magnetic resonance imaging showing the avascular necrosis of the femoral head (*arrow*)

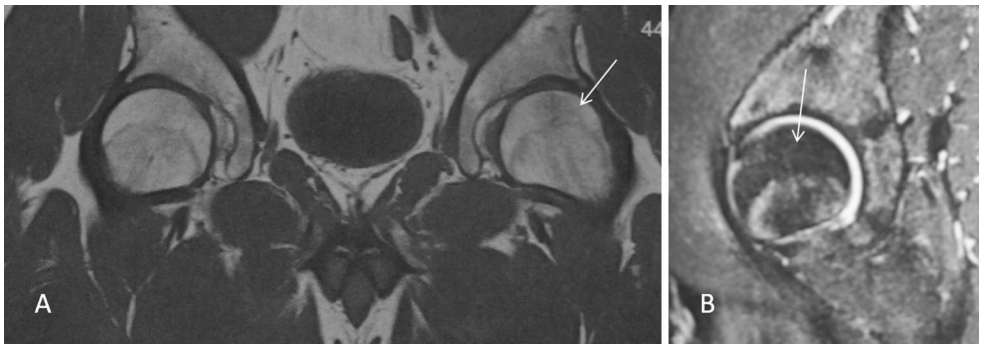

Fig. 2 Magnetic resonance imaging showing the resolution of the avascular necrosis

Discussion

The global rate of complications following hip arthroscopy in our present series was 14.34% (37/258). The total number of sequelae secondary to complications was 0.7% (2/258), both of them due to lateral femoral cutaneous nerve injury: one with dysesthesias and the remaining patient with hyperalgesia.

Although our average complication rate is higher than other reviewed studies, there is an absence of severe complications that must be outlined, as well as a very low rate of injuries involving any sequelae, as previously described [20, 21, 32, 38, 39]. Hip arthroscopy appears to be safe, with the majority of complications being non-life or limb threatening. However, caution should be taken before considering hip arthroscopy a benign procedure [28, 40]. A review by Harris et al. [41] concluded that although the rate of severe complications was 0.58%, minor complications could rise up to 7.5%. The rate of complications in patients younger than 18 years old is similar to the observed in adults, with no significant differences (1.80%) [42].

The global rate of complications in Gupta's systematic review related to hip arthroscopy was 4.5% representing 285 complications on a total population of 6277 hips [40]. When breaking them down into minor and major complications, the rates were 4.1 and 0.41%, respectively. The most frequent causes among the minor complications were neurapraxia and heterotopic ossifications and among the major abdominal fluid extravasation followed by instrumental breakage [40].

Patient positioning is a common source of complication in hip arthroscopy [23, 32, 38]. Due to the conformation of the hip as a constrained joint with a thick capsule and large muscular envelope, traction must be applied through the ipsilateral leg in order to place a distracting force over the joint to allow a safe instrumentation and arthroscopy of the central compartment. The overall rate of neurapraxia has been reported between 0.48 and 20% [23, 32, 38]. However, in relation to neurological injury Dippman et al. [43] pointed out that within hip arthroscopy, 46% have nerve dysfunction during the first six postoperative weeks, and an 18% still have symptoms 1 year later, without a clear relationship with the time of traction during surgery. The same work advises to avoid such injuries using the less possible traction for the necessary distraction, avoid trapping the scrotum and labia with the traction post, use well-padded perineal post and, if necessary, use Trendelenburg positions to favor less traction [18, 20, 40, 43–45]. Pailhe et al. [46] described in their series 2% of neurological injuries associated with traction mechanism, including a review describing incidences of 0.9–25%, although the review included as well patients operated of femur fractures. In our series, we present a 1.1% (3/258) rate of pudendal nerve lesions, in direct relation with the traction mechanism, but if all the neurological lesions are taken into

account, including those related to portals, our series features a 3.1% (8/258) rate of neurological injuries, of which 2 remained as sequels. The territory of the lateral cutaneous femoral nerve was the affected nerve in six patients, related to the mid-anterior portal in all cases. In the two cases described with painful scars, one was over the mid-anterior portal and the remaining over the lateral portal, but with scar symptoms exclusively, without a component of meralgia. The painful symptoms were resolved in both cases after excision of scar by Friedrich's excision under local anesthesia. Excessive traction, as described by Elsaidi et al. [47] based on their anatomical study, favors a greater proximity of neurological structures such as the lateral femoral cutaneous nerve (LFCN) to the arthroscopical portal, thus promoting its injury. Telleria's study suggests that maximum traction on patients with special sensitivity brings neurological injury such as the sciatic nerve, although intraoperative measurements demonstrate that 75% of these injuries recover during the first 15 min after release of traction [48]. According to several authors, the use of well-padded perineal posts has been of great aid in order to prevent perineal problems [40, 43]. Pads greater than 10 cm in diameter distribute traction in a better way and decrease pressure in the perineal area, together with decreasing the time of traction to the minimum possible [23, 46, 49, 50]. Other factors such as the lateral position, the use of distractors with external fixator, or older age, have also been associated with different risks of injury in different studies [46, 51]. The three cases of our series with perineal injury were in relation to the absence of the usual post or a change in the usual table, which led to a degree of different traction in those patients. The anatomical position has also been previously studied [40, 52], concluding that it is the lateral femoral cutaneous nerve (LFCN) that has more risk of injury due to its proximity to the portals. It is estimated that despite the low risk of damaging neurological structures in relation to the portals, in the case of the LFCN it may reach 0.5% [53].

Regarding other injuries associated with traction, although several studies [54–57] referred to vascular and neurological injury in their series in relation to traction at the level of the foot and ankle, we did not observe any case of injury in relation to the distraction within the foot and ankle. Along the same lines, although several studies describe injury of the sciatic and femoral nerve by continuous traction, we did not detect any of these problems in our series [20, 21, 32, 37, 58].

The risk of bleeding related to portals is described only in case reports, with injuries due to direct laceration of the superior and inferior gluteal arteries [59, 60]. The reaming of CAM-type lesions contributes to bleeding by radiofrequency ablation. To our knowledge, anemia or bleeding in relationship to hip arthroscopy is not yet described; however, we have found a decrease in hematocrit and rate of hemoglobin in these type of patients 24 h after surgery that despite not having clinical consequences it could be potentially dangerous in patients with previous hemoglobin or hematocrit rates in the lower limits or with mild anemia, as it has been published in series of knee anterior cruciate reconstruction [61]. In a separate group of 35 patients of our series, we analyzed the levels of hematocrit, hemoglobin, number of red blood cells, observing a decline of nearly 6 points of hematocrit and two g/l of hemoglobin, without significant changes in the levels of leukocytes, platelets or biochemical parameters [62].

Instrumental breakage occurred in our series in 1.9% of patients, also being a common complication in the literature, rating up to 0.1% [20, 21, 42, 54, 55], although its incidence is reduced as the learning curve of the surgical team [54] progresses. The joint's curvature favors forcing the surgical instruments to tear or even break [15, 20, 59, 63]. It should be outlined that the experience has been directly linked to a lower rate of complications [45, 54]. Moreover, supervision by an orthopedic surgeon experienced in hip arthroscopies favors the decrease in complications in a significant way [64]. None of the cases in this series required extra surgical measurements than the one used to remove the material, without influencing the course of surgery and without altering the recovery of patients.

It is estimated that up to 20% of labral injuries could take place during hip arthroscopy [33]. Domb's study describing a careful entry technique of the nails through the initial portal situated the labral injury rate in 0.67% [34]. These data were not collected in the present series and could thus be considered as a limitation of this study.

Due to lack of traction or difficulties in accessing the femoroacetabular space, cartilaginous lesions can occur that despite the reported rates of 1% it is speculated that it could be even higher, although it is not reported a worse progress in these patients [21, 31, 32]. Authors recommend keeping a minimum distance of 10 mm at the femoroacetabular space [65]. These data were not collected in the present series and could thus be considered as a limitation of this study.

We have had two cases of dermal burns regarding the use of radiofrequency vaporizer. More specifically, the cause could be described by its use in both cases without using the vacuum system and leaving it open, allowing the accumulation of high-temperature serum in direct contact with skin. A similar case has been already described by Curtis et al. [66], with second-degree burns treated conservatively (with a favorable progress and corrected after a 6-week period), due to the same reasons.

Regarding the patient's temperature, several studies use a preheated saline serum that seems to reduce the

temperature drop of patients undergoing hip arthroscopy, with 2.7% rate of hypothermia cases [67]. As a routine practice, we do not measure the patients' temperature.

One case of infection was observed during the present study, which although it seems to have a clear relationship with a hematogenous spread of oropharyngeal origin, it did require a debridement arthroscopy. The patient could return to fully sports competition 4 months after the first surgery. Reported rates of infection are uncommon as in the present series [4]. Published studies show a small incidence of infections within hip arthroscopy [20, 32, 42], recommending a prophylactic dose of antibiotic in anesthetic induction as antibiotic coverage [38].

The risk of avascular necrosis (AVN) is considered more a theoretical possibility than real according to the number of published cases [22, 31, 68–70]. The resection limits are considered as very important elements to take into account in order to prevent this injury as well as traction times [31, 71]. The recommendations for avoiding AVN of the femoral head consist in taking care to avoid excessive traction and intra-articular pressure and carefully avoid the side vessels during femoral neck epiphyseal osteoplasty [40]. Its causes are thought to be due to excessive traction of lateral vessels, direct injury from the osteoplasty or a greater intra-articular pressure [68, 69, 72]. In this series, we have detected a case of avascular necrosis, which improved after non-weight bearing with the help of two crutches during 8 weeks and the external application of magnetic fields 30 min/day. The patient returned to sports 6 months later with a complete restitution of the cephalic image by MRI. After the described progress of the case, we doubted in its description, if it was really a postsurgical avascular necrosis or a transient regional osteoporosis. With the MRI images, we cataloged the injury as an avascular necrosis with favorable outcome.

We have not detected any instability secondary to surgery. It has always been considered this possibility especially in patients with hip dysplasia undergoing hip arthroscopy due to labrum injury or impingement from femoral overgrowth. Several studies describe this complication and the important role that plays the labrum [25, 45, 73–77]. In order to prevent this complication, the preservation of the labrum as well as avoiding capsulotomy between portals has been previously described [40, 78]. The sectioning of the zona orbicularis acts as a locking ring that prevents instability [79]. Moreover, the iliofemoral ligament repair can also promote the stability of the joint [25, 74, 75]. The role of the ligamentum teres also seems to favor the stability of the hip, without any clear evidence in the literature [80, 81]. The recommendations for avoiding iatrogenic hip dislocation are [25]: avoid excessive acetabular resection in dysplastic hips, consider capsular plication in patients with ligamentous laxity and attempt to preserve the zona orbicularis; if incised, then perform a repair at the end of the procedure [40].

We have observed a case of stress fracture of the femoral neck. Mardones et al. [82] recommended less than 30% resection of the femoral neck's diameter as a greater resection significantly decreased the amount of energy required to produce a fracture. The recommendations for avoiding femoral neck fracture are counsel patients on restricted weight bearing after femoral neck osteoplasty and avoid resections greater than 30% during femoral neck osteoplasty with cortical notching or also of the burred region [13, 27, 40, 45, 55, 83]. In our case, the two circumstances could have contributed to stress fracture.

Regarding the occurrence of heterotopic ossifications, rates of 1.6 to 12% have been reported, especially in male with FAI [21, 30, 36, 84, 85]. However, in the present series, no heterotopic ossifications were observed. These figures are much lower to the observed in surgeries such as hip replacement where rates vary from 20 to 30% [36, 86]. Most of heterotopic ossifications are asymptomatic and are usually described as casual findings in routine radiological controls, without giving major complications regarding mobility [36]. The use of NSAIDs such as naproxen has shown a decrease in the occurrence of heterotopic ossifications by more than 10 times, although it does not eliminate the incidence [87]. A study of different types of NSAIDs has shown differences with the use of indomethacin regarding common NSAIDs such as naproxen, reducing rates to 1.8% (compared to 8.3% of naproxen) [36]. Our series presented a rate of 1.55%, without representing limitations of mobility in the affected patients. All our patients were treated with diclofenac for a minimum period of 10 days and then taking it to demand according to the pain.

We found three cases in the present study with capsular adhesions that forced an arthroscopic surgery of artrolysis at 4, 6 and 8 months, respectively. Subsequently, the recovery was complete. Adhesions are usually found between capsular face of the labrum and the articular capsule [38]. These adhesions affect the articular sealing and contribute to joint pain. It is considered that early mobilizations decrease the risk [88] and may even affect by increasing tension in the iliotibial band requiring corrective surgeries [38].

Regarding the iliotibial band injuries, Luyckx et al. [89] already related this syndrome with knee surgery, specifically due to the rotational change following a total knee arthroplasty. However, to our knowledge, no study group has yet related the iliotibial band syndrome to hip arthroscopy. Since we consider this fact as a complication of hip arthroscopy, representing 9 of 37 cases studied, it justifies 24% of the complications of our series [90]. If we do not consider the complication of iliotibial band as a

complication of hip arthroscopy, but a problem derived from the improvement of the mobility of the patient, the rate of complications in our series is 10% (26/258).

Major complications

No extravasation of fluid into the abdominal cavity was observed in the present series. Our working pressure is 60–80 mmHg. Several case reports have described fluid extravasation into the abdominal compartment during hip arthroscopy [26, 91–99]. The rate of this complication has been estimated to be 0.16% based on studies of more than 25,000 arthroscopies, caused mainly by the use of excessive pressure pump and psoas tenotomy at the beginning of the surgery [96]. Despite being a rare complication, it is recommended to include it as a possible side effect in the informed consent due to the potential hazard that entails. Although it is considered as a vital risk and having described cases with cardiorespiratory arrest [92, 94], it has not been linked to any death as the patient with cardiorespiratory arrest survived, as it is described in the original study (although several future manuscripts have stated that the patient finally deceased) [26, 92, 95]. The following recommendations have been made regarding extravasation of fluid: avoid hip arthroscopy early after acetabular fracture, perform iliopsoas fractional lengthening toward the end of the procedure, perform frequent abdominal compartment palpation, monitor intraoperative hypotension and avoid high-pressure pump [40].

We have not detected any case of deep vein thrombosis (DVT) or pulmonary embolism. Enoxaparin 40 IU/24 h for 10 days was prescribed to all patients. Our results are in line with the previous review by Bushnell et al. [100], with an absence of DVT in over 5000 patients. Published studies report isolated cases, even with fatal result in some case [19, 29, 101–104]. Salvo et al. [28] estimate the risk of DVT at 3.7% in hip arthroscopy. Anyway, antithrombotic prophylaxis is especially recommended in patients with thrombotic risk factors [105].

Studies relating obesity and hip arthroscopy have not established a clear relationship between an increase in the number of complications and obese versus non-obese patients [106], despite its relationship to an increased risk of complications in orthopedic procedures [107, 108]. Neither the presence of previous knee arthroplasties led to surgical modifications in these patients [109].

Limitations

Several limitations should be considered when reviewing the present manuscript. First of all, the definition of complication is a controversy by itself. The criteria proposed are an event that requires a second procedure, specific drugs, or more than 6 months of recovery [39]; however, this definition can minimize problems such as asymptomatic iatrogenic injuries over the cartilage or labrum. Severe complication is defined as one that puts the patient's life or limb function at risk, although it could also bias the results, as an avascular necrosis of the femoral head, commonly asymptomatic, could be considered as both severe or mild complication. In order to follow more reproducible criteria, we included in our systematic review the classification of Clavien–Dindo describing levels of complication depending on their therapeutic management (Table 4). The reproducibility of this classification can help systematize the type of complications of our surgeries [110].

Our findings need to be interpreted within the inherent limitations of a retrospective review, which is prone to data inaccuracies and missing data.

The follow-up as set up in 1 year as the purpose of this study was to detect complications related to surgery at an early stage. However, it could be considered as a limitation for detecting possible problems that may appear later. Simpson et al. [59] report that in patients with symptoms of labral injury without obvious osteoarthritic changes it is possible to predict an improvement in 80% of patients, 15% without obvious changes and even a 5% worsening, 1 year after surgery. However, it is important to clarify that none of the complications was detected beyond 6 months in cases of longer follow-up.

Several studies report that the main cause of a second hip arthroscopy is the lack of a correct resurfacing (79–92%) [31, 111, 112]. Therefore, re-arthroscopy is not a complication but an inadequate treatment.

Last of all, in the present series data of labral injuries or cartilaginous injuries produced during hip arthroscopy were not collected and although there is no relationship proven between these lesions and clinical consequences [31], we believe that these should be collected systematically both for its extension, depth and location.

Conclusions

Hip arthroscopy involves a low number of major complications, and although these may be life-threatening, applying the appropriate preventive measures they can be minimized. The number of minor complications is greater, although very few sequelae have been observed. Currently, different preventive measures have been described in order to reduce these complications. In conclusion, hip arthroscopy is a safe surgical procedure although experienced and trained surgeons that can apply the preventive measures and avoid complications should perform it.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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